Supplement to

INFORMATION LETTER

NATIONAL CANNERS ASSOCIATION

No. 1073 | Washington, D. C. | February 12, 1946

Proceedings of the N.C.A. Technical Sessions at the Atlantic City Convention

This Supplement to the INFORMATION LETTER of February 12 (Convention Issue) contains reproductions of the papers presented at the two Canning Problems Conferences and the Sanitation and Waste Disposal Conference held during the week of the 1946 Convention of the National Canners Association at Atlantic City, N. J. Also the Supplement reprints two of the addresses made at the general sessions of the Convention—those of Dr. Charles Glen King, Director of the Nutrition Foundation, on nutrition research and of Norris H. Sanborn, of the N.C.A. Laboratory, on the industry's plant sanitation program. Although the latter were first published in the Convention Issue, they are included in the Supplement because they contain material related to subjects taken up in more detail in the Conference sessions. Since Dr. King and Mr. Sanborn addressed general sessions of the Convention prior to the technological sessions, their speeches are placed first in this issue. The remainder of the technical papers are grouped and published in the same general sequence in which they were presented at the conferences. All papers in this Supplement are reproduced in full. Copies of this Supplement are being mailed to all canner-members. Additional copies will be available on request, and it is also planned to make available separate reprints of the individual papers for those who prefer them in that form.

The Canning Industry's Sanitation Program

By N. H. Sanborn, of the N.C.A. Research Laboratories

OPENING SESSION

The handling, storage or manufacture of any food product for human consumption demands the proper appreciation and application of sanitation. Just what do we mean by "sanitation"? The dictionaries define sanitation in terms of health. One dictionary, for example, defines sanitation as "The removal or neutralization of elements injurious to health." As society advances in its thoughts, new concepts of sanitation are developed. It is not sufficient that a food be handled solely under conditions which will insure freedom from elements injurious to health, although that is, of course, an indispensable requirement. Conditions must be such that the food will not become contaminated with any foreign substance whether harmful or not. Sanitation stresses utmost cleanliness. As applied to foods, "sanitation" may be defined as the maintenance of conditions under which foods are handled, stored, or manufactured in a clean, healthful manner which will preclude the incorporation of any extraneous substance.

In the canning industry as in any other group there are some who are more progressive than others. The progressive canner has long been aware of the benefits of sanitation. To an individual packer good sanitation means a clean plant, a better product, compliance with state and federal sanitary requirements and an asset which can be capitalized for its advertising value. A clean plant is necessary to secure freedom from rodents and insects. Good sanitation results in more efficient operation, better workmanship, fewer accidents, and better personnel relationships.

Better plant sanitation can be made an asset to the canning industry as a whole. The producers of certified milk or meat packers operating under inspection by the Bureau of Animal Industry enjoy a high degree of public confidence. From the standpoint of safety from infectious micro-organisms canned foods are unexcelled. The canning industry could and should match this high degree of excellence with an equal excellence in sanitation. The sanitation of the canning industry as a whole is good. The record proves that. Let us all strive to make it better.

There are two ways of obtaining better sanitation: (1) through legislation and (2) through education. Legislation is necessary in the interests of public welfare, but it is through education that the goal will be reached.

Let us first consider the legislative aspect of sanitation. Under the original Federal Food and Drug Act of 1906, the Food and Drug Administration could sustain a charge of insanitation only by demonstrating the actual presence of objectionable material in the product itself. The Act of 1938, on the other hand, goes far beyond this, providing as it does in Section 402(a) (4), that a food shall be deemed to be adulterated "if it has been prepared, packed, or held under insanitary conditions whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health." Under this section, frequently referred to as the "may have" section, it is no

longer necessary to establish the presence of filth or an injurious substance if convincing evidence can be presented to establish that conditions were insanitary so that the product may have become contaminated. Notice has been served upon the food industry that greater attention will be paid to this provision of the law by Federal Food and Drug inspectors.

Last summer an inquiry was addressed to Dr. Paul B. Dunbar, Commissioner of Food and Drugs. I know you will be interested in the following portion of Dr. Dunbar's reply, which gives an insight in the thinking of the Food and Drug Administration.

Eleven-point Inspection

"Here are some of the points with which the inspector must concern himself as far as sanitation is concerned:

1. Is the plant in an area where a rodent problem is to be expected?

2. Is cannery waste or other waste dumped close to the plant, so as to constitute an insanitary nuisance and become a breeding place for flies or other vermin?

3. The building itself is a matter of concern. Is it properly screened?

4. Is the equipment kept clean? Is it so constructed that all parts are accessible for cleaning?

5. Is the drainage such as to permit the accumulation of spillage, offering additional breeding places for insect life?

6. Is the plant rodent- or cockroach-infested?

7. Are raw materials and manufactured products properly protected?

8. Is the brining equipment properly handled to be sure that the brine is clean from start to finish?

9. Are toilets properly constructed and well-screened from the remainder of the plant? Are they kept clean?

10. Are soap and hot water provided so that hands may be washed after absences of employees from work? Are these facilities used?

11. Are the employees themselves clean? Do they indulge in insanitary practices?

Those are the things I think of insofar as a cannery is concerned. With the answer to all of these questions, however, the inspector then has a decision to make as to whether the conditions found unsatisfactory *may* cause the food product being prepared in the plant to be contaminated with filth. If the answer is in the affirmative, it is our view that the output of the firm is adulterated immediately upon its delivery or offered delivery for shipment in interstate commerce."

Each state likewise has its law pertaining to the sanitation of foods. In some cases, they employ the identical wording of the "may have" provision of Section 402 (a)(4) of the Federal Food and Drug Act. In addition, some states provide detailed regulations regarding canning operations. The conscientious canner has no difficulty in meeting or even exceeding state or federal regulations. Indeed, canners welcome such regulations when properly administered. This is evidenced by the current activities of several state canners associations which are cooperating with enforcement agencies in the formulation of new regulations and dissemination of information on existing requirements.

The educational approach to better plant sanitation is an industry problem. The National Canners Association as early as 1913 appointed a Committee on Sanitation which recommended a set of sanitary requirements for canneries at the Association's Convention in 1914. As a guide to canners, the National Canners Association in 1923 adopted a comprehensive Sanitary Code.

More recently it has become evident that the canning industry should reexamine its position with respect to the newer concepts of sanitation; not in regard to the wholesomeness of canned foods because they have been and are safe, but rather to the esthetic concepts of sanitation. In November, 1944, at Dr. Esty's request, an official of the Food and Drug Administration attended a meeting of the Technical Committee of the NCA Western Branch Laboratory to discuss the Federal sanitation program. Two months later the San Francisco Laboratory employed a trained sanitarian to conduct a sample survey of a number of representative canning plants. In a comprehensive report the conclusion was drawn that better plant sanitation is possible and that in the great majority of cases conditions encountered reflected a lack of recognition rather than neglect on the part of the management. These conclusions have been verified in a large number of surveys conducted in many parts of the country, and have pointed up the part that education can play.

The NCA has been aware of the need for improved plant sanitation and has discussed this subject with individual canners over a period of years. The results of the original Western Laboratory survey served to focus attention on the need for an intensified sanitation program. Last March, the Administrative Council with the approval of the Board of Directors made provision for work on canning plant sanitation under the direction of the Executive Committee of the Scientific Research Committee. Both the Washington and San Francisco Laboratories immediately started on an educational program. Owing largely to geographical reasons, the principal emphasis of the programs of the two Laboratories differed.

The San Francisco Laboratory added two trained sanitarians to its staff. Individual plant surveys were conducted on a request basis. In all, 185 surveys were made. A number of canner meetings was attended which afforded an opportunity to discuss their sanitation program. The first of a series of sanitation circulars was distributed to all NCA members. This circular brought to the attention of canners excerpts from current publications and an outline for a sanitary survey. Through the efforts of the San Francisco Laboratory the University of California conducted a special training course in plant sanitation. Those who completed this course, together with sanitarians recently employed by individual canning companies and members of both NCA Laboratories engaged in sanitation, have provided the industry with a nucleus of trained personnel.

The San Francisco Laboratory will continue to conduct surveys of individual plants. Canners in the Western area who have not availed themselves of this service are urged to request it. Reports are confidential. The San Francisco Laboratory will continue to meet with canner groups and expects to inaugurate regional short courses in canning plant sanitation.

The Washington Laboratory was confronted with the problem of how best to conduct its sanitation program. Covering as we do the entire area east of the Rocky Mountains, the procedure of making wholesale surveys on a request basis would demand a staff of sanitarians out of proportion to the other activities of the Laboratory. Also, it was thought, surveys on less than a wholesale scale would reach principally the sanitation-minded canners who would be least benefited by such surveys. Accordingly, the Washington Laboratory has stressed the educational approach through state canners associations, although not ignoring the value of individual surveys.

A number of special meetings were arranged through the cooperation of state secretaries. Such meetings enabled the Laboratory to discuss fully and frankly the need for better plant sanitation and to discuss ways and means whereby the Association could be of most value to canners. From our experience with these meetings we have reached the following conclusions:

State Meeting Conclusions

1. Any program of sanitation can best be carried out under the immediate control of state canners associations through a committee on sanitation.

2. Cooperation with the state board of health or other state agency charged with canning plant inspection is desirable. In considering a program it should be conditioned to meet local requirements. There are certain states which have set up efficient systems of inspection which go beyond that required by the Federal Food and Drug Administration. Other states either make no provision for organized inspection or do it on an inadequate scale. The consensus of several group meetings was that effective state inspection was desirable and that the means of obtaining this was properly the func-

tion of the state association. Several state associations have inaugurated action along this line. The Laboratory has conducted spot surveys for one state association for its guidance.

3. The Laboratory should prepare circulars on the various phases of canning plant sanitation and eventually prepare a complete manual.

4. The Laboratory should assist state associations in conducting regional schools where persons connected with individual canning plants can receive instruction on canning plant sanitation. The Washington Laboratory has been actively engaged in such assistance. To date, three schools or short courses have been held, one by the Michigan Canners Association at Michigan State College, a second by the New York Canners Association in cooperation with the New York State Agricultural Experiment Station, and the third by the Wisconsin Canners Association at the University of Wisconsin. Registered attendance at these schools ranged from 116 to 175. The Tri-State Packers Association has scheduled a school to be held at the University of Maryland during this month. Several other state associations have indicated a desire to hold similar schools.

State Sanitarians

We have suggested to state associations the desirability of their employing a sanitarian for several months during the canning season to conduct plant surveys. The Wisconsin Canners Association did so last summer and it is expected that other state associations will do likewise this year. The Laboratory will be glad to cooperate with state association sanitarians. The Washington Laboratory has conducted plant surveys with state inspectors to study their methods and has contacted both state and federal officials charged with food sanitation. We have conferred with and accompanied the NCA West Coast sanitarians on a number of surveys for a mutual exchange of information. To a limited extent, the Washington Laboratory has made plant surveys at the request of individual canners. Papers on canning plant sanitation have been given at several annual conventions of state associations. We have endeavored to have two members of our staff conversant with canning plant sanitation and one of these attended and actively participated in the special training course given by the University of California.

As to this year's program, the Washington Laboratory feels that it is important to complete our contacts with state associations preferably through specially called meetings. We are prepared to conduct spot surveys for their information, to assist in short courses and to render such other assistance as they may desire. It is our intention and also that of the San Francisco Laboratory to accumulate and disseminate information to aid canners in maintaining better plant sanitation. In so far as time and personnel will permit, we shall endeavor to make surveys for individual canners upon request.

The National Canners Association desires to act as a clearinghouse for information and to guide canners in solving their sanitation problems. However, sanitation is an industry problem. It is our hope that every canner will realize that better plant sanitation is possible, that it will be of benefit to his own company, and to the canning industry as a whole. The larger companies may find it advantageous to employ trained sanitarians. Other canners should appoint responsible employees in the capacity of plant sanitarians. In the smaller canneries, the activities of a plant sanitarian need not occupy his entire time but it is important that other duties be of such a nature as not to interfere with his primary function—that of plant sanitarian.

To summarize, then, the industry's sanitation program can be made successful by the joint efforts of individual canners, state associations and the National Canners Association. I have tried to indicate what has been done and is being done by the latter two in the way of organization and education. The final measure of success, however, will depend on the extent to which individual canners avail themselves of the information and methods at their disposal, and bring sanitary principles to bear on every detail of factory operation. This may take a little time, but the interest and enthusiasm with which the program has met thus far leave little room for doubt of success.

Nutrition Research and the Food Industry

By Charles Glen King, Scientific Director, Nutrition Foundation

SECOND GENERAL SESSION

Several years ago, at one of those delightful research conferences where guests are encouraged to be human, I met a young man on the tennis court who introduced himself as Fred Stare, a student of my friend, Professor Elvehjem. Later, having followed the young man's professional career with interest because he seemed to be indeed promising, I invited him to serve as editor of Nutrition Reviews. Dr. Stare accepted the editorship, as a research scientist, and then to my pleasant surprise, I found that his first job as a chemist was in his father's cannery. His interest in nutrition had a very practical background, and I would like to take this occasion to thank his father for doing us a good turn.

One of the greatest difficulties faced by scientists in talking with non-scientists about foods and nutrition, is to keep before them an appreciation of the complexity of anything that is living. This difficulty is present, whether the topic be an apple or the human body. But in a similar vein, one hears many executives express an ardent desire that scientists might appreciate more fully the complexities of business management. That very situation provides a basis for the strong current trend of having an organizational setup in which the research director shares in the top level of administration. Without such a provision for close coordination between research and policy-making groups, an organization exposes an Achilles heel.

The food industry, of necessity, must work with extremely complicated and often very perishable materials. Such things as bacteria, green leaves, proteins, fats, vitamins and enzymes simply cannot be handled in a modern, practical sense, unless one recognizes their tendency to change.

A second great demand upon the food industry is with regard to public health. When the food intake is too greatly simplified, animal and human health break down. Hence those who are entrusted with the public's food supply are extremely vulnerable to public confidence and good will.

Because of the delicate situation in which food must be made bacteriologically safe, without destruction of desirable nutrients, the canner has long recognized the pressure from both directions. Nevertheless, it is sometimes forgotten that so far as health is concerned, malnutrition can be just as damaging as bacteria. The process is slower, but when a man's teeth decay, or his liver, kidneys and heart fail to function properly, he is no better off than when attacked by bacteria. He can be just as sick as if bitten by a bug.

Our universities and medical schools generally provide the most efficient environment to develop the more fundamental or exploratory types of research, such as isolating, measuring, and discovering the functions of individual nutrients. They are also in the best position to explore many aspects of food intake in relation to health, to initiate new areas of genetic research, and to explore the basic chemical and physical properties of specific materials. There is every reason to keep such projects out in the open.

The Nutrition Foundation was organized by the food industry to develop broad research projects of that nature, in the public interest.

Foundation Program

Aside from war work, which received more support than any other part of our program until this year, the Foundation has centered its interest on the following areas:

First, to discover and identify all of the nutrients such as minerals, vitamins, amino acids, sugars and fats that may be essential for complete nutrition,

and then find how much of each is ideal for health in man and in his useful animals;

Second, to find how to measure each nutrient accurately, either as it comes into being on a farm, or later takes its course through factories and kitchens to the ultimate consumer;

Third, to discover how each nutrient functions, that is, how it does its work inside a living cell, including the human body;

Fourth, to find how each nutrient can be used to best advantage in the protection of health and in the satisfying of human wants. This type of research should extend through the full life span, including pregnancy, lactation, youth and old age. It should include such stresses as illness and extreme ranges of environment from the tropics to the arctic and up into the stratosphere.

Fifth, to facilitate education, so that the science of nutrition can be made effective without undue loss of time.

You may ask, "Is the science of nutrition so basically important, or has the stress of war led to over-emphasis upon its place in the sun?"

College Nutrition Research

One answer to such a question is to cite the fact that our highest ranking graduate schools, medical schools and schools of agriculture are steadily strengthening their nutrition research programs, both in personnel and laboratory facilities. Specific examples may be cited in Harvard University, Cornell University, University of Wisconsin, Yale University, University of Texas, Vanderbilt University and Washington University. Each has underway a vigorous expansion in nutrition research and graduate training.

Another answer can be given in terms of specific research programs.

At Washington University, for example, Dr. Cori has just added an exciting chapter in the biological sciences, in tracing the course of sugar as the body starts to burn it or convert it into fat. In doing so, he isolated a number of enzymes and then discovered how two of the body's hormones function, on a molecular basis. This is the first time that scientists have found such a clear basis for understanding how hormones accomplish their control of the body. One of the hormones is insulin, and medical people therefore have a much clearer picture of what has gone wrong inside the body when diabetes occurs. Insulin has been a great boon to humanity in controlling the worst aspects of diabetes, so that a patient can keep going about his work. But picture for a moment how much more it would mean to this and future generations if we could find what causes diabetes, and then find how to prevent it. Continued research in nutrition provides a good prospect of achieving such a goal.

Tooth Decay

Another major disease that is influenced very markedly by nutrition is dental caries, or tooth decay. A recent report from an army officer, Lt. Colonel John C. Brauer, illustrates the extent of tooth decay among the young men of America:

"Records reveal that, at the beginning of the war, nine out of every one hundred selectees were rejected for one or more dental deficiencies. The only requirement for entrance into the Army was that there should be at least three serviceable, opposing, natural masticating teeth (i. e., chewing teeth), and three serviceable, opposing natural incisors (or biting teeth). Dental defects were the leading cause for rejection, eye defects ranked second, mental and nervous defects third, and cardiovascular defects fourth.

"The rejection of this large number of men necessitated the lowering of the dental requirements to meet the demands for induction and manpower. Accordingly, the dental requirements were reduced in March, 1942, and again in October, 1942; since then approximately one selectee per one thousand was rejected for dental deficiencies. Men can now qualify dentally for the Army who have two jaws."

The Foundation has four projects under way that deal with the causative factors underlying tooth decay. There is good reason to feel confident that prevention of tooth decay will be greatly enhanced by improvements in food intake patterns in the immediate future. It doesn't require a prophet to see that each step of that nature toward better public health is going to affect the industry.

In England, for example, data are beginning to show that their radical changes in dietary pattern during the war were not only accompanied by the lowest infant and maternal death rates in their history, and the lowest child death rates from tuberculosis, but also were accompanied by a marked decrease in the incidence of tooth decay. Their diet was monotonous, but it was clearly of higher nutritive quality than before the war. It is perfectly feasible to relieve the monotony without sacrificing nutritive quality.

There is good reason to pay special attention to human maternal feeding problems. A group at Harvard University has reported startling findings from over ten years of systematic study of the effects of maternal diets upon the health of their infants. For example, they found that the chance that an infant would be classified as robust, or nearly perfect in health, was four times greater when the mother's nutrition was good or excellent, compared to those whose diets were poor or very poor. On the other hand, the proportion of infants with health records classed as poor, was twenty times greater when the mothers' diets were poor. Intermediate types of diets resulted in intermediate degrees of health.

Continued study and independent checking will be necessary to gain complete acceptance of their findings, as in all such work. The problem is not a minor one, however, on other scores. In recent years there have been nearly twice as many infant deaths associated with physical deformities at birth as there have been from four common diseases of childhood combined, namely, diphtheria, measles, whooping cough and scarlet fever. Dr. Joseph Warkany, at the University of Cincinnati, has shown close relationships between poor nutrition and physical deformities in experimental animals at birth, but there is no comparable information regarding human nutrition.

Unless one is close to the research laboratories, there is a tendency to gain an impression that most of the important problems are already solved. In nutrition research, there is no risk of reaching a saturation point in the near future. Among other basic findings that have been reported in the scientific journals within the past year, aided in part by grants from the Foundation, are the following:

1. Dr. Icie Macy Hoobler's group in Detroit has reported extensive, new information on the composition of mother's milk. Even in this field, which seems so elementary to human feeding, there is still a large amount of work to be done.

2. Dr. Otto Bessey and his associates in New York are developing micro techniques of analysis, so that nutrition surveys can be conducted rapidly and objectively among large population groups, and especially in the schools. Two members of their staff, with assistants, recently collected tiny blood samples—about three drops—from the finger tips of 80 students in about an hour, and by the end of the next day had completed accurate analyses for vitamin C, vitamin A, carotene, protein, hemoglobin and phosphatase. To this list they expect to add soon, two more vitamins and one mineral, without requiring a larger blood sample. Measuring one's nutritional status, which is basic to checking progress toward better food habits, can thus be approached in a manner that removes a large portion of the present guesswork.

Protein Requirements

Again, one might suppose that everything of a practical nature would be known by this time about human requirements for protein, including the use of foods like milk, eggs, and meat. Yet most of our knowledge in terms of the basic units or proteins, remains to be published. Within the coming year, an excellent series of reports will probably appear in this field, based on the first broad, well controlled approach to

the problem. Meanwhile, on the practical side, physicians working with the Surgeon General's office have reported their discovery that by using high protein diets, the convalescence time after injury from infectious hepatitis, or jaundice, can be shortened by 50 percent or more.

For several years prior to 1945, chemists had been studying an elusive new member of the vitamin B-complex, called folic acid, without knowing whether it would be of value in human nutrition. Meanwhile, they studied chicks, rats, guinea pigs, monkeys and butterfly wings. During the last three months of 1945, four different medical groups reported its curative use in human nutrition, and had agreed that it affords protection against two heretofore baffling diseases, one, a common type of anemia, and the second, a form of subtropical dysentery, called sprue.

An important aspect of recent studies of folic acid and other members of the vitamin B-complex, is with regard to their ease of destruction. This whole area of research is likely to stimulate much greater emphasis upon foods that are fresh or at least prepared and distributed with great care. The dignity of fresh fruit, and a sirloin steak without whiskers, is likely to return.

Food Industry Research

In the over-all development of research supported by the food industry, there is unquestioned need for strengthening two additional major types of organization; *first*, to conduct research within each individual company, and *second*, to develop somewhat broader areas of research which are largely noncompetitive, but of immediate interest to several firms.

Studies of a basic nature, such as I cited in the Nutrition Foundation program, augment and strengthen the work of individual company research laboratories and also the association type of program. I have seen, already, repeated examples of how the exploratory work supported by the Foundation increases the interest of company executives in providing greater support for their own research men; and I have seen four industry-wide, or association type, programs develop in part as an outgrowth of our activities. Each new basic discovery along the research frontier creates added opportunities for the research men in a given company to improve and extend their own activities. In other words, alert, research-minded companies accelerate their own programs and serve the public more effectively roughly in proportion to the basic scientific advances that become available to them. As an example, note the current interest of the food industry in new methods of measuring amino acids, and in estimating the quality of protein foods in terms of biological assays. Or note the effect that a chemical method of measuring vitamin C has had upon nearly every company that deals with fruits, vegetables, or fluid milk. Unquestionably, the food industry now provides the public with superior products because its chemists have been able to detect changes in vitamin C content during production, processing and storage. The resultant leads have meant better retention of flavor and attractiveness, in parallel with increased nutritive value. This advantage applies to those who are developing improved foods, irrespective of whether they are fresh, frozen, canned or dehydrated. In the cereal field, vitamin B_1 has played a role about as conspicuous as that of vitamin C in fruits and vegetables. I believe we are going to see, within the very near future, a similar series of rapid developments relative to folic acid and other new, unstable members of the vitamin B-complex. Each respective company will accordingly extend its own research activities and by so doing will improve its products and processes, and the health of the consumer.

In addition to the work of individual company laboratories, one should emphasize, too, the role of trade-type research programs, such as the excellent work conducted by the National Canners Association.

The Refrigeration Research Foundation is also developing a strong research program. Other groups are organized along definite commodity lines, such as those dealing with milk, sugar, meat, corn, bakery goods, and citrus products.

It is a pleasure to comment specifically on the project devoted to a study of the nutritive value of canned foods carried out by your own group and the Can Manufacturers' Institute. The American public, and especially the armed forces, owe you a distinct debt of gratitude. I know that many of you spent a great deal of time on the project, and I would guess that the venture had been satisfying. It was no small task to handle the details for making extensive analyses of 823 samples, in scattered university laboratories, and including 32 different products. Nevertheless, beyond the immediate value of the data, such work stimulates continued efforts to improve products and processes and to search for superior sources of raw materials.

The American pattern of food consumption is still far from being ideal, both in regard to its nutritive quality and in relation to such practical aspects as convenience, cost, and enjoyment.

The first major world-wide organization to get under way as the war drew toward a close was the group now officially constituted as the Food and Agriculture Organization. The man selected as President is Sir John Orr, a dean among the world's nutritionists. This development is indicative of the growing world-wide conviction that the science of nutrition is destined to play a vital role in further progress toward human health, scientific agriculture, and improved economic stability.

Safe Practices in Retort Operation

By Ira I. Somers, N.C.A. Western Branch Laboratory

CANNING PROBLEMS CONFERENCE

Introduction

Safe recommended processing procedures or operations must be followed if safety of canned foods is to be assured. The reason for this is that processes for canned foods are established by tests made under carefully controlled conditions of time and temperature with the cans in an atmosphere of pure steam (free of air), and when these processes are applied in commercial practice, the identically same conditions must be provided. Commercial experience may indicate in some instances that all the precautions discussed in this paper are not necessary, because installations and operations which do not meet these recommended requirements have not as yet given serious trouble. However, conclusions drawn from commercial experience alone are often very misleading. It must be remembered that processing deals with microorganisms which are not present in the same resistant forms in all cases, and therefore a lot of the good luck which some have had has been due to the fact that these organisms were not present in the food. Nevertheless, in establishing a process or operating procedure, which is designed to destroy organisms of a certain heat resistance, the possibility of their presence in every can must be assumed and processing gauged accordingly.

To assist in the prevention of spoilage and loss is one of the functions of the laboratory, and it is for this reason that the recommendations given in this paper are called to the attention of the packers at this time. These recommendations are based on experimental work plus experience, and if followed should prevent spoilage from underprocessing, with the possible exception of certain special types of thermophilic spoilage.

The installation and operation of the retorts must be considered as one of the most important factors in the entire procedure of canning. There is more to retorting than merely filling a retort, closing the door, turning on the steam and watching the temperature. To be sure, these are the basic steps, but the factors related to these steps are actually the conditions which determine the completeness of the process given. The arrangement of the cans in the baskets, and the perfora-

tions in the baskets, together with the method of venting employed during the coming up time, determine the uniformity of heat distribution, and hence the uniformity of processing throughout the load in the retort. Also the adequacy of the process is dependent upon the accuracy of the thermometer, the carefulness of the operator in reading it, plus the care observed in assuring that the full time is given.

Effect of Air in the Retort

When a retort is filled with "pure" steam at a given pressure, the temperature will be the same at every spot in the retort, but if other gases, such as air, are present this may not be true. Experience has indicated that air in the retort during processing may cause serious underprocessing.

The danger of air in the retort in relation to a loss in sterilizing value can be explained by a consideration of some of the properties of these two gases, air and steam. For example, steam serves as an excellent means of carrying heat to cans, while air may even act as an insulator to prevent their being heated.

Steam serves as a good medium of heat transfer because of its "stored energy" properties. The "stored energy" of steam results from the fact that in the manufacture of steam considerable heat (970 B.T.U.'s) is required to change boiling water at a given temperature to steam at the same temperature, and this extra heat is carried with the steam as latent heat or "stored energy." Upon condensing, such as occurs on cans in the retort, this latent heat is given up, which means that the steam has been able to "carry" an "extra load" of heat from the boiler to the retort. Air does not exhibit such properties at this temperature. The fact that steam condenses, while air does not, increases the hazard even more because when an air-steam mixture flows toward a surface colder than the steam (such as cans in the retort) the steam condenses, leaving the air behind. This not only tends to prevent additional steam from entering that area, but the air acts as an insulator and prevents the cans from being heated by conduction.

Even small amounts of air among the cans in the retort may result in serious underprocessing. This was demonstrated by the experiences of 1940 and 1941. During these seasons several outbreaks of spoilage from underprocessing were observed in cases where the charts, and temperature records indicated the full recommended process had been given. On investigation by thermocouple studies, it was demonstrated that low temperature areas or "air pockets" were persisting among the cans during part of the process.

As a result of these findings, experimental work was carried out to determine the most satisfactory method for air elimination from retorts during the coming up time. Over 500 heat distribution tests were made and, based on the results of these tests, procedures for venting of retorts were established. Copies of these venting procedures are being placed in the Sixth Edition of Bulletin 26-L, now being prepared and for this reason they will only be mentioned in this report.

The types of venting procedures found to give the most satisfactory results were:

For Horizontal Retorts:

1. Venting through multiple one-inch vents discharging directly into the atmosphere, with one vent for every 5 feet of retort length.
2. Venting through multiple one-inch vents discharging through a manifold with one vent for every 5 feet of retort length.
3. Venting through a water spreader installed along the top inside the retort.
4. Venting through a single 2½ inch vent located in the top of the retort. (For retorts up to 15 feet in length).

For Vertical Retorts:

1. Venting through a one-inch vent in the lid of the retort.
2. Venting through a 1½ inch overflow pipe.

For the most satisfactory results, all vents should be equipped with gate valves, and the steam should enter the retort at the side opposite from that at which the vent is located (in the bottom for top vents). Also in the case of horizontal retorts it is essential that the steam be jetted up into the load of cans in order to complete the elimination of air in the recommended time.

It was found in using these venting systems that in order to obtain uniform distribution the vent had to be left open for a specified time and until a definite temperature was reached depending on the size and type of vents.

It was also demonstrated by this work that temperature-pressure agreement cannot be relied upon as a criterion of complete air elimination. It was thought for some time, prior to these tests, that all the air would be out of the retort when the pressure gauge reading corresponded to the pressure of pure steam at the temperature indicated on the thermometer. However, in the course of these studies, runs were made where temperatures among the cans were as much as 100°F. below the retort temperature, while at the same time there was perfect temperature-pressure agreement.

Factors Influencing Efficiency of Venting Procedures

It was found while studying venting that a great many factors influence the ease of obtaining uniform heat distribution. They are discussed below.

BASKETS AND TRAYS

Various types of trays and baskets are used for holding in retorts and they are either good or bad from a heat distribution standpoint, depending upon their degree of interference with steam circulation. Tests have shown that strap iron or wire trays and crates are very desirable because their construction permits the free flow of steam in all directions among the cans and assures an effective sweeping out of the air. Perforated crates or gondolas, on the other hand, are, in many cases, unsatisfactory because it is possible for the cans to cover the holes in the bottom and thus prevent the steam from sweeping up through the load. For best heat distribution in such equipment the cans should be either jumbled or horizontally stacked. To allow for adequate steam circulation in perforated baskets and trays, and especially if cans are stacked vertically, the bottoms should be perforated with at least the equivalent of 1-inch holes on 1¾-inch centers. If the holes are fewer than this, poor heat distribution may result. However, baskets with fewer holes have been used satisfactorily by placing a wire mesh on the bottom. A 4-mesh or coarser wire screen made of 13 to 16 gauge wire keeps the cans from blocking the holes, thus permitting the steam to flow up around the cans and force the air out of the load.

ARRANGEMENT OF CANS IN A BASKET

Three different methods of stacking cans in baskets are used: vertical, horizontal and jumble stacking. Vertical stacking can be used with satisfactory results with proper trays. Care must be taken, however, to avoid stacking of cans in vertical columns because with such an arrangement air is trapped between the ends of the cans and steam is prevented from contacting the cans at those places. The most satisfactory arrangement of vertical stacking is to stagger the cans, which will help to permit adequate steam circulation and heat application to all surfaces.

In vertical retorts the tops of cans should not project above the rims of the crates, because if one crate rests directly on the cans in the crate below it, steam circulation may be considerably hindered and also the cans may suffer seam damage and consequently may leak.

Horizontal stacking, or the placing of cans in a basket in a horizontal position, permits fairly good circulation of steam throughout the load, and is recommended as the method of stacking to be used in large gondolas. It cannot be used, however, when processing certain products such as asparagus or asparagus style snap beans because they must be placed in the retort in a vertical position.

Jumble stacking of cans allows for

uniform and rapid steam circulation and has proven to be the most satisfactory method of stacking cans from a heat distribution standpoint. The only danger of this method is in the use of large cans, because serious denting of the sides and seams may result. Jumble stacking has been used satisfactorily with cans as large as No. 2. One of the primary drawbacks to stacking cans in this manner is that the capacity of the retort is decreased about one-fifth, due to the irregular arrangement of the cans.

DIVIDERS

Dividers of various types are sometimes used to separate cans of one lot from those of another in the same crate or basket. Such dividers should be made of material of sufficiently large mesh to permit adequate steam circulation. The most satisfactory dividers are those made of loose-meshed material such as onion sacks, or fish nets with mesh of at least ½-inch or larger. Perforated metal dividers are satisfactory if they have 1-inch holes on 1¾-inch centers, or the equivalent of this in holes of other sizes. However, dividers with fewer holes than this should not be used because poor heat distribution may result. Burlap sacks, boards, sugar sacks, towels, or similar materials should not be used as dividers under any circumstances because they greatly interfere with steam circulation, and tests have shown that products separated by such materials do not receive the full process.

Perforated metal dividers have the disadvantage that they do not permit full use of all baskets at all times. For example, there is frequently a space left under a divider when changing from one code or one lot of cans to another, and this space could be filled with cans if other types of dividers were used.

BAFFLE PLATES

Perforated baffle plates should not be used in the bottoms of vertical retorts because they tend to direct the flow of steam around the load rather than up through it. This is especially true when perforated crates are used, because the holes in the baffle plates and those in the bottoms of the crates frequently do not match, causing the holes to be shut off completely so that steam cannot penetrate up into the load.

Maintenance of Proper Temperature

Every retort should be equipped with an accurate mercury-in-glass thermometer having a temperature range of not more than 100°F. (for example, 170°F.-270°F.) and with scale divisions of one or two degrees each—never greater than two degrees. This thermometer should be clean and located on the retort so that it is easily readable. Also it should be checked and standardized at least once each year against an accurate standardizing thermometer.

If a temperature recorder is used, its use should only be in conjunction with a mercury thermometer, and temperature readings entered on the retort operation record should never be taken from the chart but from the thermometer. The chart merely serves as a continuous temperature record for future reference. In adjusting the recorder pen, the pen should be set to record the exact temperature of the mercury thermometer or less. It should never be permitted to record a higher temperature. The reason for this is that as long as it is adjusted to record slightly less than the thermometer, and the record shows the recommended temperature, the operator is certain that the temperature of the process was equal to or greater than that recommended. If, on the other hand, it is adjusted to record a higher temperature than the mercury thermometer indicates, and the chart shows the recommended process, the product will be underprocessed by the amount that the chart is off, but there will be no way of knowing this from looking at the chart. Thus, anyone studying these records at a later date would be misled as to the safety of the pack.

A pressure gauge should never be used to indicate the temperature in the retort, because the ones commonly found on retorts are entirely too inaccurate, and can be put out of adjustment rather easily. Also pressure gauge readings may be effected by air in the retort, and thus give a higher reading than would be normal for that particular temperature. In addition, pressure gauges are effected by altitude and must therefore be adjusted at the locality at which they are to be used—an adjustment which most canners are not equipped to make with the required accuracy.

Timing Processes and Keeping Records

Accurate timing of a process is very important because if the full process is to be given the full time must elapse. Timing of a process should be accomplished as follows: record on a process record blank the time the steam was turned on, the time at which the retort was up to temperature, and the time when the steam was turned off. Subtract the time when the retort was up from the time when the steam was turned off and record this value in the space headed "length of process." The value to be placed in the space "length of process (or cook-minutes)" should always be determined by making this subtraction and not by merely recording the recommended value, because this subtraction method serves as a check to assure that the full time has elapsed. Timing should be done with an accurate watch or clock—never by approximating or guessing, and when recording, the exact time of day should be recorded.

In addition to the times mentioned above, the following items should be recorded on the daily process record card: product, temperature chart number (if used), batch number, retort number, size of cans, number of cans, code on cans, and mercury and recording thermometer readings at the beginning and end of the process. The purposes of obtaining such information are several. They provide the opportunity for checking back on process operations in the event of spoilage and may help to establish the cause of such spoilage. Also in such cases they serve as protection for the retort operator in the event blame is fixed for the cause. In addition, by having codes and numbers of cans, it is possible to pick out in a warehouse all cans from a retort load which may have been underprocessed and thus prevent the danger of their getting out to the consumer. Also, if checked daily by management, such records indicate possible errors in processing soon enough so that the material can be removed from the warehouse before it spoiled.

Another factor, which comes under the jurisdiction of the retort operator in the prevention of spoilage, is the task of assuring that all crates or basket loads of cans enter the retort and are processed. The operator should establish some regular routine of filling and emptying retorts to make certain that unprocessed cans do not get into the warehouse. Where it is not possible to handle it otherwise, some type of tag which changes color on processing might be added to each basket as a safeguard.

The Use of Break-Point Chlorination and Sterilized Water in Canning and Freezing Plants

By J. E. Hall and C. C. Blundell
PictSweet Foods, Inc.

CANNING PROBLEMS CONFERENCE

While food packers have always been interested in plant sanitation, the intensive study of this subject is now being undertaken by both the National Canners Association and the National Association of Frozen Food Packers.

There are many phases of the whole sanitation problem which must be studied and solved such as the growing and handling of the raw products, plant layouts, equipment design, lighting, and rodent and insect elimination, but probably the most offensive and discouraging condition to combat in canning and freezing plants is that of odors and slime. The formation of slime indicates the presence of bacteriological contamination and results in contamination of the finished product. Authorities vitally interested in the canning and freezing industries,

have repeatedly stressed cleanliness of plant and product and a pure water supply.[1, 2]

Our work has emphasized the great need for further extensive bacteriological work. It is possible that serious pollution might occur from development of injurious bacteria reproducing symbiotically within the slime masses.[3, 4, 5] Such pollution within food industries not having a final sterilizing step may easily cause public health problems.[6]

Cleanup Procedure

The present accepted cleanup procedures are based primarily on the manual removal of slime and odors through the use of water, steam and the many good detergents on the market for this purpose. Little thought, generally, has been given to the prevention of slime formation whether it is that growth formed during the hours of operation and completely removed at night or the accumulation of growths before the detergents are used. It is believed that in many cases, plant management, when observing slime growths in the plant, has placed the blame for this condition on the failure of the cleanup crew to use sufficient water, either hot or cold, and steam to properly clean the plant and equipment.

It is well established, although not fully appreciated in this industry that waters, considered pure enough for drinking purposes, will cause and sometimes support slime growths. Perhaps the best evidence of this is the difficulty some cities have with slime in water mains and the difficulty they have had in preventing bacteriological contamination of the mains even after marginal chlorination of the water.[3, 4, 6, 7] With this knowledge, that the plant water supply can cause, and sometimes support slime growths, it is not surprising that the canning and freezing industries have had difficulty in controlling slime growths. It has been our experience that the heaviest slime growths occur generally where the most water is used such as in flumes, washers and gutters.

The water supply industry, in its search for ways to remove tastes and odors remaining after marginal chlorination, has developed what is known as break-point chlorination.[8] It is not new, having been known since 1919 although the intensive study of it was not undertaken until 1939. Since then, as the value of break-point chlorination became generally known, its use gradually spread to where it is now practised by some 200 cities.[9]

The theory[8] which seems to be well proven, is that when small amounts of chlorine are added to water, the chlorine becomes loosely linked with other substances in the water. These combinations have odors and flavors that the public usually associates with chlorinated water. If the rate of chlorine application is increased until the concentration becomes great enough to oxidize these chlorinated compounds, the objectionable flavors and odors are eliminated leaving water without objectionable odors or flavors. This point, in water chlorination is called the "break-point."

Not all waters have the same break-point and not all waters will have the same free chlorine residual at the break-point, but the procedure does make it possible to maintain in city water supplies, free active chlorine residuals beyond the break-point rate of application to insure more effective disinfection of water supplies without objectionable flavors or odors.[9] The American Journal of Public Health in an Editorial in the July, 1945, issue, has described break-point chlorination as "perhaps the most significant advance in the disinfection of water supplies since the introduction of chlorination at Boonton in 1908."

Last spring, we gave consideration to the use of in-plant chlorination of the total plant water supply for the purpose of (1) using in canning and freezing plants the safest water recommended by the water industry, and water which would not in itself cause or support slime growths, (2) utilizing the free chlorine residual remaining after the break-point as a sterilizing agent on such equipment, floors and gutters as the water might come in contact with and (3) determining if the use of sterilized water resulted in lower bacteria counts in the finished product.

The term "sterilized water" is used to distinguish water treated to and beyond the break-point from water which has only been treated by marginal chlorination. This latter type water will be referred to as "Chlorinated Water."

Experimental projects[10] were ultimately set up for three plants, a corn cannery, a pea cannery, and a freezing plant. The cooperation of the Western Branch Laboratories of the National Canners Association was requested and secured in making bacteriological surveys of the corn and the pea plants. The Wallace and Tiernan Co. cooperated by furnishing the equipment and supervising the installation and operation of their chlorinators in these plants.

Prudence dictated, and still dictates, a very cautious approach to the chlorination of the general plant water supply for either canneries or freezing plants. It is a new field for these industries although in-plant chlorination has been used by dehydrating plants.

Before chlorinating the general plant water supply at the pea plant during actual operations it was decided to determine first the maximum residuals of free chlorine which could be carried in the water without objectionable odors or flavors and second, the effect if any, varying residuals of free chlorine would have on the product.

The maximum free chlorine residual which could be carried without objectionable odors and flavors was in excess of 10 ppm. and was not determined. Samples of peas were packed with water containing as high as a calculated 1,000 ppm. of free residual chlorine, processed and later examined over a period of time. The examination demonstrated, in these samples at least, that free residual chlorine even in the excessively high ranges had no effect, favorable or unfavorable on the product.

With this background of experience, and feeling reasonably safe, the rate of chlorine application was gradually increased beyond the break-point, to insure adequate sterilization of the water supply, taking into consideration bactericidal velocity as related to contact time and temperature. All water used in the plant, including drinking water, was treated.

General plant observations were made on slime growths and it was noted that whenever water was in regular or intermittent contact with such equipment as washers, elevators, inspection tables, gutters and floors, no slime growths occurred. In some places, such as the sides of elevator pockets and a narrow strip along the outside edge of the inspection belts which the sprays missed, a very slight slime formed after several days operation.

Bacteriological Survey

After the plant had been operating for several days with sterilized water, the National Canners Associations technologists Dr. Somers and Miss Zuch of San Francisco conducted a fifteen day bacteriological survey of one pea line in the plant. During the first five days of the survey, sterilized water was used in the plant and then the chlorinator was turned off for the next five days. At the end of the tenth day the chlorinator was turned on again and the survey continued for another five days. During this period, samples of water were drawn and tested for bacterial count per cc, from one pea line morning and afternoon at (1) the Olney washer, (2) a point halfway through the hydro-geared grader, (3) the end of the hydro-geared grader, (4) the end of the flume to the blancher (5) the blancher overflow (6) the end of the flume to the quality grader and (7) the end of the flume from the quality grader. In addition a count was made each time on an unprocessed can of peas. During this same period observations were made on the growth of slime.

The line remained in good sanitary condition for the period of time sterilized water was used in the plant. After the chlorinator was turned off there was a gradual increase in slime accumulations until at the end of the five day period it was considered objectionable. It was not possible to keep the line in as good condition with

detergents and manual scrubbing as it was when sterilized water was used.

The bacteriological results paralleled the slime observations. In the Olney washer the bacterial count increased 56 times over the previous high during the period in which sterilized water was used, and once the chlorinator was turned on the counts dropped. Perhaps the most striking results were the counts obtained on the blancher overflow water where it increased, at the end of the fifth day to 67 times the average count obtained during the period in which sterilized water was used. All locations showed significant increases in bacteriological contamination when sterilized water was not used.

In view of the results obtained in the pea plant, the work including the bacteriological work and the experimental work on the effect of varying residuals of free chlorine on the product was duplicated in a corn plant regularly using city chlorinated water. With the experience gained on the use of sterilized water, even better plant conditions were maintained during the period when sterilized water was used. The bacteriological results again showed significant increases when sterilized water was not used. No product affect was found even when excessively high residuals of free chlorine were tried experimentally.

Season-end Conclusions

Toward the end of the season the nightly cleanup procedure was to raise the free chlorine residual in the plant general water supply, remove coarse material such as husk, and cobs, and to wash the equipment and floors down thoroughly with cold water. If a slime growth or an off odor was noted in some particular place, it was removed and instructions given to the cleanup crew to wash that particular place down with cold water at each cleanup whether the place looked dirty or not. If this was not sufficient, a spray, using only a small quantity of water was directed to that place. No detergents were used at any time. Good housekeeping standards were maintained at all times during plant operations by regular cleanup crews. At the conclusion of the season the plant and equipment were clean and there were no off-odors.

The freezing plant, packing a general line of vegetables and a few fruits, used sterilized water practically all of the season. No bacteriological work was done but as the operating personnel became familiar with the judicious application of the water for cleaning purposes, the plant conditions improved. At the end of the season the plant and the equipment were clean and there were no off-odors. The same general cleanup procedure was being used at the end of the season as was finally adoped at the corn plant.

In all of our plants as a part of our routine quality control system, samples of both processed and unprocessed canned products and samples of both frozen and non frozen products are drawn every half hour from each line and examined by our plant control technicians. In no case at any plant using sterilized water has any product affect, favorable or unfavorable been found which could be attributed to the use of sterilized water.

Less Corrosion

No corrosion of equipment has been found which could be attributed to the use of sterilized water carrying a free residual chlorine. It is the consensus of opinion of the plant personnel that if there was any difference, it was that less corrosion occurred this year than in previous years.

At each of the three plants the sterilized water was used for general drinking purposes, even during cleanup periods when the rate was increased. As to the water flavor, those conducting the work could not be certain whether or not the chlorinator was on or off except when high free chlorine residuals were carried for cleanup purposes.

In view of the preliminary nature of this work it would seem advisable for the members of the industry to approach the use of sterilized water for all plant purposes cautiously, under controlled conditions, with the assistance of those familiar with water chlorination and water chlorination equipment, and those technologists familiar with canning procedures. Residuals carried during operation and during cleanup in this work have purposely been omitted because those residuals might not be the ones necessary or advisable with other types of water or products. The rate of chlorine application may be found to be that required to obtain the maximum destruction of the bacteria in the water within the time elapsing between the application of chlorine and the use of the water, providing it is determined that that rate of application does not cause difficulty.

Advantages

While not a cure-all in itself, in-plant chlorination where it can be applied seems to offer, on the basis of the preliminary work, the following advantages:

(1) The use by food plants, where it is determined it can be used, of practically sterile water, and water of a type which has received the approbation of public health authorities interested in public water supplies. In addition, one of the two substantial sources of bacterial contamination of the plant is eliminated.

(2) Facilities in the plant to increase the chlorine dosage during cleanup periods so that every hose connection in the plant is a source of water with sterilizing properties, even though it might be found, for some reason or another, such as phenol contamination of canning plants, that sterilized water cannot be used during actual packing operations.

(3) The prevention of slime growths and off-odors, particularly in those inaccessible, hard-to-clean places, rather than the removal of such growths and odors once they have developed.

(4) The operation by the plant superintendent of the kind of plant, from an odor and slime standpoint, he has always wanted to operate.

(5) The basic value of a clean product packed in a clean plant.

Acknowledgments

Without the whole hearted cooperation and assistance of a good number of people this project could not have been carried out on the scope it was and under the carefully controlled conditions it was. Among these are L. L. Brotherton, C. L. Kirk, E. J. Watson, E. H. Hermanson, Ralph Ramsey, George Butler and V. L. Ledum of our company, and our very good friends Mr. E. A. Heiss of the Wallace and Tiernan Co., and Dr. Esty, Dr. Somers and Miss Zuch of the Western Branch Laboratories of the National Canners Association.

References

[1] MICROANALYSIS OF FOOD AND DRUG PRODUCTS, Food and Drug Administration Circular No. 1, Chapter 2, Plant sanitation sections A, B, C, D.

[2] CLEANLINESS—THE PRICELESS INGREDIENT, Wendell Vincent, *The Canner*, March 10, 1945.

[3] BACTERIOLOGICAL IMPROVEMENTS OBTAINED BY THE PRACTICE OF BREAK-POINT CHLORINATION, A. E. Griffin and N. S. Chamberlin, *American Journal of Public Health*, March, 1945.

[4] WATER-BORNE GASTRO-ENTERITIS, Charles R. Cox, *Journal of American Water Works Association*, September, 1939.

[5] BACTERIOLOGY OF WATER PIPES, Carl Wilson, *Journal of American Water Works Association*, January, 1945.

[6] RESEARCH AND QUALITY CONTROL OF PRECOOKED FROZEN FOODS, B. L. Hutchings and C. F. Evers, *The Canner*, Jan. 5, 1946.

[7] CONTROL OF IRON AND SULFUR ORGANISMS BY SUPER-CHLORINATION AND DE-CHLORINATION, L. J. Alexander, *Journal of American Waterworks Assn.*, Dec. 1944.

[8] TASTE AND ODOR CONTROL WITH BREAK-POINT CHLORINATION, Wallace and Tiernan Co., *Technical Publication No. 207*.

[9] EDITORIAL: SUPERCHLORINATION AND BREAK-POINT CHLORINATION, *American Journal of Public Health*, July 1945.

[10] The discussion following is based on unpublished company reports by J. E. Hall, and C. C. Blundell of PictSweet Foods, Inc., and unpublished data obtained by Dr. Ira Somers and Miss Nelda Zuch of the National Canners Assn., on this subject.

Color Measurements as Objective Tests for Fruits and Vegetables for Canning

By A. Kramer, University of Maryland and H. R. Smith, N.C.A. Research Laboratory

CANNING PROBLEMS CONFERENCE

Color is the most evident and frequently the most important factor in the description of canned foods. It may also serve as an indicator for other quality factors such as maturity or ripeness. Although much progress has been made on the identification of the plant pigments and their role in plant physiology, comparatively little has been done towards measuring the relative amounts of these pigments in samples of prepared foods.

The pigments involved in the color expression of fruits and vegetables are the chlorophylls, carotins, and anthocyanins. For a discussion of the identity, isolation, and determination of the above pigments in their various isomers, reference is made to Strain[1] and Zcheile.[2]

Factors affecting the color of processed foods are first operative on the raw product. Hereditary varietal differences are important. Tendergreen beans, for example, are naturally greener than Refugee beans. Frequently the stage of maturity of the raw product is associated with color; thus, as the tomato matures, the original green turns to a whitish green as the chlorophyll disintegrates, then to a light yellow as the carotin begins to develop, and finally through orange to red as the lycopin content increases.[3] Seasonal effects are influential. Beets maturing in the fall usually have better color than those maturing in the hotter summer.[3] Canning procedures also have their effect on the final color of the canned product. The color of Blair processed peas, for example, is different from the color of peas canned in the ordinary manner.

Methods of Color Measurement

In laboratory work on the development of objective tests for canned foods, we have been investigating methods for measuring the color of prepared foods.

In developing methods for measuring the color of prepared foods, it was not considered necessary to make quantitative determinations of pigment content. The relative intensity of the total color, or of some critical color fraction can be used as a numerical notation of the color for practical color evaluations. The ultimate criterion of the validity of any such method is, of course, its relation to organoleptically determined color ratings evaluated statistically.

The simplicity of the method for use by the average technician was also considered. The few previous attempts to measure the color of canned foods were not entirely satisfactory for two main reasons. First, the instruments previously available were too complex or too cumbersome, and second, those instruments that were not too complex were not sufficiently accurate, especially for measuring borderline cases. More recently however, we have been fortunate in having the use of more refined instruments which greatly increase accuracy and at the same time are simple to operate.

The instruments used in these studies fall into two general categories which may be classified as (1) psycho-physical, that is instruments which give a numerical value of the color as seen by the eye of the observer, and (2) physical, that is actual physical measurements in terms of wave length and per cent transmittance at a given wave length.

The Disc Colorimeter

The Keuffel and Esser Disc Colorimeter is an example of a psycho-physical instrument. For a detailed description of the disc colorimeter and the Munsell color system employed with this instrument, reference is made to Nickerson,[4] and to the Symposium on Color.[5] This discussion will be limited to a description of the operation of the color machine. The eye piece through which observations are made shows a field divided into two semicircles. The object whose color is to be measured is seen in one of the semicircles, while the color against which the sample is to be compared is projected to the other semicircle from a disc. The color on this disc may be adjusted or changed by covering its surface with various cards of definite specifications. Thus, for example if tomatoes are to be measured, a red card, a yellow card, a black card, and a gray card are all placed overlapping on the disc. The image of these cards is then spun rapidly so that the individual colors are blended and merge into one color expression when seen in the semicircle through the eyepiece. If, for example, the observer notes that the blended color is more in the direction of yellow than the tomato, he will increase the percent of the area occupied by the red card at the expense of the yellow card; or if the merged color appears too light, he will increase the percentage of the black card on the disc, and so on until the combined color of the cards matches as closely as possible the color of the tomato. The per cent of the area of the disc occupied by each color card is then recorded.

The results may be reported in a number of ways. If the Munsell system is followed entirely, then values for hue, chroma, and value may be obtained by calculation from the percent data recorded by the observer. The term *hue* refers to the color itself, that is whether it is red, or purple. The term *chroma* refers to the intensity or strength of the color, for example, whether the color is a deep red or a light faded red. The term *value* refers to the amount of black or gray in the color complex. These calculated values may be considered absolute quantities. For our purpose, the results may be expressed usually in much simpler terms. To follow up the tomato example, the factor of hue is far more important than the other color attributes; thus, the red-yellow index, or the proportion of the area occupied by the red card to the proportion of the area occupied by the yellow card, gives a satisfactory indication of color differences. This is essentially the same method that is written into the Food, Drug, and Cosmetic Act where the equivalent of an index of one or better is required for the tomatoes to be above substandard in color.

The following procedure was used to establish a color test when the disc colorimeter was employed: (1) The three or four color cards of a known Munsell notation were selected which when combined matched the color of the product. (2) Several samples selected for their wide variation in color were tested in order to check on the range available with the particular color cards. (3) A large number of samples was carefully prepared so that duplicate cans would be as much alike as possible. One set of these samples was tested with the machine, and a duplicate set was rated organoleptically by competent observers in order to establish the validity of the test, to find the simplest satisfactory way of presenting the results, and also to suggest objective limits for label statements.

Spectrophotometer

This method involves the extraction of the color from the product by the use of one or more solvents, and the measurements of that colored solution in the spectrophotometer in terms of percent transmittance of light at a specific wave length.

A translucent solution transmits its own color and absorbs the complementary color. For example, a purple solution of beet juice transmits the purple color but absorbs the complementary green color. Expressed graphically, when the degree of transmission is plotted against wave length in terms of millimicrons, the lowest percent transmittance and highest absorption is at the wave length of 525, or at the green color. When the wave length is changed to about 600 (yellow in color), there is a sharp increase in transmittance and decrease in absorption, and finally when the wave length is increased to 700 (red in color), practically all the light is transmitted, since the wave length now approaches the color of the solution itself. In most cases it is the transmittance of the complementary color that is measured.

The greater the intensity of a color, that is, the greater the pigment concentration in the solution, the more completely will the complementary color be absorbed and thus show a lower per cent transmittance. The re-

sults may be expressed simply in terms of percent transmittance of the complementary color, with the colorless solvent serving as reference at 100 percent transmittance. Thus, the greater the intensity of the pigment, the lower the percent transmittance.

In establishing a spectrophotometric test, the procedure used was as follows: (1) A suitable solvent or combination of solvents was selected for extracting the desired pigment. (2) The dissolved pigment was examined for turbidity since turbidity interferes with transmittance measurements. (3) The transmittance curve was plotted against wave length for extracts of several samples varying widely in color in order to find the wave length showing the widest range for the particular pigment, and in order to establish the optimum dilution of the color extract. (4) A large number of samples was carefully prepared so that duplicate cans would be as much alike as possible. One set of these samples was then tested at the proper dilution at the selected wave length, and a duplicate set of samples was rated organoleptically by competent observers in order to establish the validity of the test and to suggest objective limits for label statements.

Comparison of Disc Colorimeter and Spectrophotometer Methods

Each method has its advantages and limitations. In the preparation of the sample, the great advantage lies with the disc colorimeter in that the sample is measured practically as it is removed from the container. Some extraction procedure is required for the photometric sample unless the pigment is water soluble.

Disc colorimeter data show the color attributes and permit an analysis of the differences in color. However, the results are at times difficult to explain and compare.

The spectrophotometric method, on the other hand, is least influenced by the human element, does not require special training, can be obtained by color blind individuals, and is less cumbersome. It is much easier to keep the cuvettes of the photometer clean than to keep thumbprints and dust particles from the color cards.

Beet color is a good example of a pigment that may be more easily measured on the spectrophotometer, since the pigment is water soluble and the liquor may be measured directly. Tomato color on the other hand might more easily be measured on the disc colorimeter because of the complexity of pigments involved.

Recently, Kelley et al. (1943), have shown the relationship between the Munsell color cards and spectrophotometric measurements, and developed relatively rapid methods for calculating spectrophotometric data in terms of Munsell notations, and vice versa. Such calculations, however, can be made only if the spectrophotometric measurements are made of the reflected color of opaque materials, whereas, the measurements made above were of transparent solutions. Measurement of reflectance, however, does not provide opportunity for obtaining a representative sample as does measurement of transmittance where the entire sample may be first thoroughly blended, nor does it offer the opportunity for selecting the desired pigment concentration.

Before using a particular spectrophotometer, it is extremely important to know the specifications of the instrument and to have it adjusted properly. An instrument which does not actually narrow down the light band to monochromatic light will not give results comparable to those obtained with a monochromatic instrument. When similar pigment extracts were measured on two spectrophotometers, one a Coleman monochromator, and the other a Coleman Universal, the results varied considerably. It so happened that at the wave length chosen for measuring tomato color, the two instruments gave similar percent transmittance readings, although there were considerable differences in the transmittance curves. For lima beans, however, the two instruments give entirely different percent transmittance readings, so that no comparison can be made between results obtained on one instrument and those obtained on the other.

Methods for Individual Commodities

Thus far tentative methods have been developed for the following commodities:

Disc colorimeter methods — Beans, green and wax; beans, lima; beets; carrots; tomatoes.

Spectrophotometric methods — Apricots; beans, green and wax; beans, lima; beets; carrots; corn; peaches; tomatoes.

The details of the individual procedures are available.

It should be emphasized that the methods thus far developed are only tentative. Much more extensive sampling under variable conditions needs to be done before the suggested methods can be definitely accepted as objective color tests for the different canned products. Further work is now proceeding, and more detailed reports are planned for each product separately.

Summary of Tentatively Adopted Procedures

DISC COLORIMETER METHOD

Tomatoes. Press drained tomatoes into a rectangular cell constructed of clear glass, 5 inches wide, 5 inches high and one inch deep, with the top left open. Eliminate all air bubbles, compare with the discs specified by the Munsell notation: 5R2.6/13 (red), 2.5YR/12 (yellow), N1 (black), and N4 (Gray). Divide the percent red by the percent yellow and report as R/Y index.

For a measure of variability within the can, separate the drained tomatoes by hand into the better two-thirds and poorer one-third by color and measure the color of each separately using a smaller cell.

Green and Wax Beans. Drop short cuts into the cell directly, large cuts or whole pods may need to be pressed down to avoid empty areas on the cell surface. Compare the color with discs of the following Munsell notations: GY5/6 (green), Y5/6 (yellow), and N1 (black), and N4 (Gray). For wax beans, use the following discs GY7/9 (green), Y7/9 (yellow), N1 (black), and N4 (gray).

Lima Beans. Fill the color cell as for short cuts of snap beans, compare to discs of the following Munsell notations: GY7/10 (green), Y7/10 (yellow), N7 (light gray) and N4 (gray).

Beets. If not diced, dice as closely as possible into ⅜ inch cubes. Drop into cell with no application of pressure and compare to discs of the following Munsell notations: 4R4/6 (red), RP3/10 (purple), N1 (black), and N3 (gray).

Carrots. Prepare as for beet samples, compare to following discs: 2YR6.3/15 (orange), Y812 (yellow), N1 (black), and N5 (gray).

SPECTROPHOTOMETRIC METHOD

Tomatoes. Thoroughly mix drained tomatoes by blending in a Waring blendor. To a 5 gram sample add 75 ml. of benzol, blend thoroughly, make up to 100 ml. with additional benzol. Dilute by 5 with benzol, centrifuge, measure on the spectrophometer at wave length of 485 mμ with pure benzol at 100 percent transmittance.

For a measure of variability within the can, separate out by hand one-third of the material which has the poorest color and analyze for color as above, the one-third poorer part, and the two-thirds better part separately.

Green and Wax Beans. Blend the drained beans in a Waring blendor with an equal weight of water. Transfer 20 grams of the blended material to a 400 ml. beaker with 13 ml. water and 80 percent alcohol as required, add 150 ml. 95 percent alcohol, bring to boil, filter, make up filtrate to 300 ml. with additional 80 percent alcohol, and measure on the spectrophotometer at the wave length of 665 mμ.

Lima Beans. Proceed as for snap beans but make up alcohol filtrates to 250 ml., transfer 50 ml. of the alcohol filtrates to a separatory funnel, add 25 ml. of petroleum ether, shake, discard the alcohol layer, and measure the ether layer in the spectrophotometer at the wave length of 665 mμ.

Beets. For the liquor, dilute 100 times with water and measure in the spectrophotometer at 525 mμ wave length.

For drained beets, blend with an equal weight of water, dilute a 10 gram sample with 490 ml. of water, shake well, centrifuge, filter, measure filtrate in the spectrophotometer at 525 mμ wave length.

Carrots. Proceed as for lima beans but measure on spectrophotometer at 400 mμ wave length.

Corn. Proceed as for carrots.

Apricots. Drain the can contents,* and blend the drained apricots in a Waring blendor until they are thoroughly macerated. Weigh 50 grams of the blended material and transfer to a blendor cup with a minimum amount of water, add 200 ml. ethyl ether, and blend 5 minutes. Transfer the contents of the blendor cup to a 500 ml. separatory funnel, replace the lower layer into the same blendor cup, and the upper ether phase into a narrow necked 500 ml. Erlenmeyer flask.** To the contents of the blendor cup add another 100 ml. ethyl ether, blend for 20 seconds, transfer to the same separatory funnel, replace the lower phase into the same blendor cup, and add the ether phase to the Erlenmeyer flask. Repeat the above two additional times. Distill most of the ether from the Erlenmeyer flasks, transfer the residue into a graduated centrifuge tube with four or five washings of about 5 ml. of ethyl ether each, and make up the clear ether solution to 25 ml. (Ordinarily no centrifuging is necessary but occasionally some turbidity develops; hence, all these samples were centrifuged for about two minutes at this point.) Transfer 2 ml. of the ether solution to a 50 ml. graduated flask, and make up to volume with ethyl ether. Use this diluted solution for obtaining per cent transmittance at 450 mμ ie., the yellow color, and the concentrated solution at 665 mμ for the green color.

Peaches. Proceed as for apricots.

* In order to reduce evaporation of ether during the blending process, these cans were precooled in 33° storage.

** Small quantities of water may be used to separate the phases.

References

[1] Strain, H. H., CHROMATOGRAPHIC ABSORPTION ANALYSIS, 222 pp. *Interscience Publishers*, N. Y., 1942.

[2] Zscheile, F. P., PLASTID PIGMENTS, WITH SPECIAL REFERENCE TO THEIR PHYSICAL AND PHOTO-CHEMICAL PROPERTIES AND TO ANALYTICAL METHODS, *Bot. Rev.* 7: 587-648, 1941.

[3] Hanson, James, TOMATO COLOR, *Canner*, Jan. 22: 35-36, 1921.

[4] Mozingo, P. P., TOMATO COLOR, *Canning Age*, June, 1926.

[5] Nickerson, Dorothy, U. S. Dept. Agr., *Misc. Publ. 256.*

[6] *Symposium on Color*, American Society for Testing Materials, Washington, D. C., 1941.

The Relationship of Spoilage to Rough Handling and Contaminated Cooling Water

By Charles L. Smith, of the Research Department, Continental Can Company, Inc.

CANNING PROBLEMS CONFERENCE

Several years ago, almost all spoilage from leakage could easily be diagnosed as resulting from one of many apparent causes, such as knock-down flanges, loose double seams or obvious manufacturing defects. Spoilage from leakage because of these obvious abnormalities will continue to occur, but fortunately the incidence is diminishing. During the past few years, an increasing number of samples are being reported as not clear cut as to the cause for leakage. More and more frequently the reports carry the phrase "Cans appear to have been handled roughly—otherwise, no obvious cause for leakage noted."

An analysis of available field and laboratory records and field observations points very definitely toward rough handlnig of filled cans as the explanation for the condition.

Specific instances, where facts were readily available, produced a rather consistently repeated pattern of probable cause and effect. Two salient facts are outstanding. When automatic filled-can handling equipment was employed, and where contaminated cooling water was likely, the spoilage rate increased.

The relationship of this increase to rough handling of filled cans coupled with the possibility of contaminated cooling water was investigated both in the laboratory and in the field. The results have been rather startling. It is, therefore, the purpose of this paper to consider these conditions in the light of some of the available evidence and to suggest means of minimizing the economic loss and high nuisance value of avoidable spoilage.

Obviously, if the can shows no defects in assembly or in manufacture, the only possible entry point for leakage bacteria is through an apparently satisfactory double seam. Substitute materials used in the double seam compound cannot be blamed as the probable explanation for this type of can failure. In many instances during the recent war years, substitutes were produced which actually gave better performance than the original material for which it was primarily designed to substitute. This is true in the case of the double seam compounds developed as a result of the early critical rubber situation. Yet, if the seam was well formed and the double seam compound was good, why then should there be any failure of the can through the double seam? The answer is rough handling or denting of the cans, particularly when they are wet with bacteria-laden cooling water.

The effect of dents on the ability of the well formed double seam to protect the sterile contents of the can is a very complex subject to discuss in that it is impossible to predict whether a given can with a given dent will spoil as a result of leakage through the seam. If any break occurs in the continuity of the seal, as from a dent, spoilage is possible. Whether or not leakage will result depends upon three main factors, (1) the position of the dent, (2) the force and direction of the deforming blow, and (3) the ever present question of whether the double seam compound has been sufficiently disturbed at the point so as to permit air-born or water-born microorganisms to gain entry to the can. Certain areas, particularly at or adjacent to the side-seam juncture are more prone than others to permit leakage to result from a given blow. The force and direction of the blow give rise to greater hazards in some instances than others. The ability of the double seam compound to maintain an hermetic seal under these varying conditions is always problematical and not predictable.

The medium surrounding the can at the time of a critical dent has a tremendous influence on the probability of spoilage resulting from leakage. The possibility of spoilage resulting from leakage as a result of disturbance of the double seam is greatly magnified if the can is wet at the time of the blow. This is apparent from the relative levels of contamination of air and water, particularly cooling canal water. Even very heavily contaminated air has a relatively low bacterial count—somewhere in the neighborhood of two organisms in 10 cc. or 0.2 organism per cc. On the other hand, counts of from 100 to 100,000 bacteria per cc. are not uncommon in cooling canal water. Thus a given dent permitting the entrance of even minute amounts of cooling water to the can could be very hazardous whereas the same dent admitting the same amount of air would be considerably less likely to result in spoilage of the canned food.

For example, one canner had regularly passed cans of cream style corn through a corn shaker while they were wet with cooling water. Appreciable spoilage was experienced. By changing the practice so that the cans were dry before shaking, the gross spoilage in this product was reduced 50 percent. While the cans were not actually dented, the treatment evidently caused sufficient disturbance of the double seam to permit some of the cans to suck in cooling water adhering to the seams. Some canners have been able to allow the cans to dry in the crates before discharging into automatic can handling systems. The spoilage records in these instances indicate the advantage of this practice.

In order to determine the protection efficiency of double seam compounds in the laboratory, a Standard Biological Test, better known as a Bio Test, is run. The double seam compound to be tested is applied to 307 diameter ends in the approved manner. For comparison, an equal number of ends with

standard commercial double seam compound is used. Briefly, the test consists of placing about one ounce of dried peas in a 307 x 400 can, filling the can with a weak sugar solution at or above 200° F., closing with covers bearing the test compound or control compound. Thus, a suitable medium is prepared for the support of growth of leakage bacteria should they subsequently find their way into the can. The closed cans are then sterilized at 240° F. in a standard retort. While the cans are being sterilized, cooling water is inoculated with heavily laden bacterial cultures. The organism used is one which is a rapid producer of gas in the medium prepared in the cans. The concentration of these bacteria in the cooling water is about four million per cc. High vacuums (about 16 to 19 inches) at the end of the cooling period assist the bacteria to find their way to the inside of the can in the event of a break in the seal.

"Can Killer"

After a standard period of cooling in the contaminated water, the crates of cans are removed, tilted to drain off the excess water and the wet cans are then run down an abuse hazard. This "can killer" is a series of gravity tracks which zig zag back and forth on successively lowering levels. The cans roll down one length of track, strike a metal stop, drop to the next lower track and so on. During this treatment, the cans, *especially* the groove between the lower edge of the double seam and the can body, are wet with water carrying a high concentration of bacteria. Any inability of the double seam compound to maintain an hermetic seal under these adverse conditions becomes evident after such treatment. They are examined daily, and all swells are removed from the regular spoilage examination routine. Only swells which show no obvious reason for leakage other than dents are counted as failures of the double seam compound.

Commercially acceptable compounds have a usual Bio Test spoilage rate of five to ten cans per thousand under the severe conditions of the test. These same compounds perform very well in the field under normal, or even moderately abnormal conditions with little or no spoilage resulting from closely observed runs of anywhere from 100,000 to 1,000,000 cans.

As is to be expected, some of the double seam compounds submitted for test are never approved for commercial trial in that the Bio Test spoilage rate is too high. Yet, it was with these unsatisfactory compounds that we learned some of the most significant facts concerning the relationship of spoilage to rough handling and contaminated cooling water. A compound, found to be unsatisfactory in the Bio Test, was purposely selected because it gave the highest spoilage rate of any tested during several years, 200 cans per thousand. A substantial number of cans were run, everything being uniform except for one important point. Half of the cans were run in the usual manner. The remainder were allowed to dry overnight after water cooling in the inoculated cooling water before they were sent down the abuse hazard. The results were startling and almost disbelieved by many. Those cans run down the hazard when wet showed the same high spoilage rate of 200 cans per thousand. Those allowed to dry before traveling the abuse hazard showed the low spoilage rate of four cans per thousand. Several repetitions of this test as well as similar tests which have been run in the laboratory since have produced the same type of result. The fact that many low vacuum cans were found among those allowed to dry before being run down the abuse hazard shows that while the cans leaked, spoilage did not result when air instead of water was sucked into the cans.

Another variation of the test was to run a portion of the cans down the abuse hazard after closure but before processing. After these cans had been processed and cooled in the contaminated water, they were hand cased directly from the crates. The spoilage rate was higher than the controls, indicating that the denting and its effect on resultant leakage was more severe under the conditions of this test.

It certainly is hoped that commercial handling of cans would not be as severe as that of the abuse hazard nor would one normally expect the bacterial count of cooling water to be 4,000,000 per cc. However, in some instances commercial cans appear to have been treated as rough, if not more roughly, than those in the laboratory tests, and in other instances, cooling canal contaminations have been found to be as high as 9,000,000 bacteria per cc. Fortunately, these exaggerated conditions are the exception rather than the rule. However, between these extremes and those of handling cans like eggs and using sterile cooling water, lie all degrees of rough handling and contamination.

A controlled test in a large cannery was conducted in order to establish the normal incidence of spoilage in No. 2 cans of peas in that plant under operating conditions. Comparisons were made to establish the difference in spoilage rates when running cans through the automatic equipment as compared to hand casing directly from the crates. To accomplish this, every other retort crate emerging from the canal was sent to the automatic handling line in the usual manner while the alternate crates were diverted for hand casing. The automatic equipment consisted of a crate dumper, unscrambler, elevator, gravity track and boxer. There was a total of about 1,075 cases handled in each manner. After a suitable time had elapsed, the lots were examined can for can. All swells were carefully inspected for cause of spoilage. After eliminating those few cans showing obvious defects, the spoilage was found to be 1.9 cans per thousand for the lot handled over the automatic equipment as compared to no spoilage whatsoever in the hand cased lot.

One of the most significant observations on an entire season's pack was made at one factory where peas, whole kernel corn and cream style corn were packed in No. 2 cans. Some 12-ounce vacuum packed corn was also run. There was no opportunity to make a detailed study during the operating season so that the broad aspects and implications are the only real data available. In peas, spoilage averaged about seven cans per thousand. All cans were handled over automatic equipment. Whole kernel corn was also handled over this equipment, and the spoilage rate on at least 30,000 cases ran over 16 cans per thousand. The cream style corn was hand cased. These were identically the same cans as used for the whole kernel corn, but the spoilage from all causes was less than one can per thousand. The 12-ounce vacuum packed corn was hand cased with a gross spoilage result of less than .75 can per thousand. The condition of the cooling water was not known.

There were, no doubt, factors other than automatic handling equipment and cooling canal water to contribute to the high level of gross spoilage, but the implications of the results cannot be overlooked.

In order that there is no misinterpretation of what is meant by automatic handling equipment, it is probably well to state that the term is meant to include any automatic device for raising, lowering, conveying or transferring cans from one position or location to another. Thus, bar flight elevators, lowerators, cable conveyors, gravity tracks, etc., must not be overlooked when considering rough handling of filled cans.

Automatic Equipment

With the conditions of labor shortage and absolute necessity for increased productions during the past several years, the canning industry could not have risen to its part of the task as magnificently as it did without the assistance of automatic handling equipment. It is not logical that these efficient methods will be discarded but rather that they will gain in popularity. It is logical that poorly adjusted or poorly adapted machinery can be a detriment rather than an aid. There is no criticism of automatic handling equipment as such, but it is easily recognized that without frequent inspection and careful adjustment, even properly adapted equipment might be introducing a hazard in the attempt to get efficient production with a minimum of spoilage.

One very good example of improper operation of a good piece of equipment

was found after excessive spoilage showed up in a block of 12-ounce vacuum packed corn. Examination of the spoilage showed about 80 percent of the cans to be severely dented in a rather regular pattern, all dents appearing just above the bottom seam or just below the top seam. About 90 percent of the dented cans showed these rather deep dents just to one side or the other of the can side seam. Diametrically opposite were similar deep dents. It was noted then that almost all of the dented cans had cable cuts on one seam or another just at one of the points of denting. Investigation of the cable conveyor system showed the cause.

Automatic Cable Shut-off

The cable had been running while the cans were prevented from moving forward by an operator blocking the line in order to clear out the caser at a change of codes on the cans. This particular cable conveyor was about 200 yards long and, when full, a tremendous pressure would be exerted on the blocked cans by the forward insistance of the cable. Consequently, most of the cans had rotated slightly away from the rigid side seam to the more yielding body, and the combined external pressure and high internal vacuum had caused severe dents just under the seams. Spoilage of three to six cans per thousand resulted. Also, in some instances the abrasive action of the running cable had actually cut through the lower seam. The condition was corrected immediately by equipping the line with an automatic cable shut-off in case of a can block.

In another instance, No. 2 cans discharged from a gravity track through a twist and dropped about one foot to the first dividing star in a boxer. Frequently, the cans fell on the point of the star rather than in the hollow, and severe seam dents on both top and bottom seams were found in perfect alignment. At one time, the divider had slipped sideways so that the can body struck the star point. In some instances, the tin plate of the body was actually punctured.

Labelers and casers are built to run at optimum speeds in accordance with the specifications for the machine. However, with ever-increasing demands for faster production, even labelers' and casers have been run faster than their rated capacity. In one instance of record, the speed of a boxer was increased. Since the cans would not roll down the gravity feed track fast enough to keep the machine full, the pitch of the feed track was increased with an accompanying increase in the number and severity of dents inflicted at this point. Bearing in mind that the cans were still wet with cooling water, it is not beyond reason that a few of the dents inflicted were of such a nature as to permit leakage. In this instance, a positive drive lowerator belt was installed to eliminate the trouble.

Continuous cooker-cooler units have frequently been under investigation in connection with excess spoilage. Obviously, if the equipment itself is out of adjustment and damage is being inflicted, high spoilage rates will result. Frequent instances of bacterial buildup in the pressure cooling unit have been noted, and there is little doubt but what this condition contributes considerably to the resultant spoilage because the cans emerge wet with contaminated cooling water. Subsequent dents resulting from rough handling in the conveyors and other automatic handling equipment may permit the entrance into the can of bacteria-laden water. Then, too, the fact that in some instances the cans are cooled under pressure may contribute slightly in forcing the bacteria through slightly loose seams which otherwise might withstand the effect of the internal vacuum at atmospheric pressure.

In general, though, it appears that rough handling prior or subsequent to the process has a far greater effect than the continuous cooker-cooler unit itself. For instance, spoilage to the extent of 53 cans per thousand was being experienced in cans which were handled automatically after emergence from a cooker-cooler unit. Contaminated water in the pressure cooler unit was demonstrated. Yet, when cans were caught directly upon emerging from the cooler and hand stacked for air cooling and drying, the spoilage dropped to about one can per thousand. The cooler unit was drained and sterilized with steam under pressure. The next lot of cans, cooled in reasonably bacteria-free water, still showed the same wide variation in spoilage rates when the automatically handled lots were compared with hand cased lots. Even cans processed and cooled in still retorts showed high spoilage rates when conveyed and handled on this automatic line, whereas portions of the same lots cased by hand from the crate itself showed little spoilage.

The tendency in modern canning practices is to produce higher resultant vacuums in canned foods. The reasons are, in general, twofold. First, there is an increasing appreciation of the benefits of exclusion of oxygen from the canned product. Better color, flavor and appearance are attained, and the retention of the nutritive value is increased besides a reduction of the possibilities of internal corrosion. Then too, in the case of liquid products, particularly fruit and vegetable juices, newer systems are being used where flash sterilized products are filled into cans which, after a short holding period, are then cooled with no further heat treatment. With these systems, it is necessary to fill the cans as near the boiling point as possible.

All this has meant an increase in the resultant effect of any rough handling since there would be a greater force tending to draw recontamination organisms through any deficiencies in the seal created by deformations produced by rough handling. This is especially true in connection with the spinner-cooler units which have been installed in many of the high-speed juice lines throughout the country. Inlet or discharge systems which permit the cans to receive rough treatment, especially by knocking into each other, should be adjusted to eliminate the condition. Several instances of spoilage have been directly attributable to rough handling and denting as cans emerge from the spinner-coolers.

In any particular instance of rough handling, the effect of the treatment on the seam of the can will be in proportion to the size of the can and the net weight of the contents. Treatment which would be entirely acceptable for small cans, such as for baby food, might easily lead to considerable spoilage in larger size cans. No. 10 cans, especially must be handled and conveyed very carefully. This is entirely possible. Long gravity conveyors have been observed to be entirely satisfactory for No. 10 cans where considerable care has been exercised to eliminate all rough spots and in which the cans are not permitted to bump into each other. On the other hand, dropping No. 10 cans by hand even a few inches into retort crates when loading from the discharge table of closing machines has been definitely shown to promote excessive spoilage. The seam is disturbed by total force exerted by the heavy weight of the containers. Automatic handling equipment for No. 10 cans must be especially inspected for elimination of any possibility of rough treatment.

Inspect All Portions of Line

It must be realized that except for a few special cases, it is very difficult to point to any one spot in an automatic filled-can handling system and say, "There is the source of all of your trouble." Most generally, leakage as a result of unusual disturbance of double seams wet with cooling water is an accumulation of the results of poor adjustment or poor adaptation throughout the entire system. Only a small part of the total spoilage may be contributed by any one portion of the line. The accumulation of all the small increments, however, may be an appreciable total. It is to everyone's interest to inspect all portions of each step of an automatic line to determine points which might well be adjusted to eliminate the possibility of distortion of the seams in any degree whatsoever.

Thus, from available evidence it has been shown that rough handling prior or subsequent to processing may be conducive to spoilage. There are any number of instances in cannery operations where rough treatment of cans could easily result in spoilage which might otherwise be eliminated. Some of these can be eliminated by overcoming employee indifference or care-

lessness. Spoilage hazards at other points can be eliminated by proper adjustment or proper selection of filled-can handling equipment. Instances of rough handling of filled cans have actually been observed wherein

(a) Cans have been allowed to splatter into empty crates from closing machine discharge tables.

(b) Crate bales have been allowed to fall and crush or dent cans protruding from overfilled crates.

(c) Crates on overhead monorail trolley systems have been allowed to crash into each other or into solid projections.

(d) Crates have been dropped into retorts, frequently on the top of an overfilled crate.

(e) Crate dumpers have not operated smoothly, and cans have fallen with considerable force on to each other and on to unscrambler tables.

(f) Cans have fallen on each other in being discharged from an unscrambler.

(g) Cans have been distorted in the boot of an elevator which has been set too tightly.

(h) Cans have been dented in poorly adjusted drops and twists, especially as they slide onto a cable conveyor where the cans bump into each other.

(i) Cans have been dented and distorted by line blocks in cable conveyors when the cable is allowed to run.

(j) Cans have been dented on gravity runways where sudden stops or sharp drops are possible. Bar flight elevators at the end of long steep-pitch gravity tracks have been observed to produce rather severe seam dents.

(k) Cans have been dented by automatic casing equipment which was out of adjustment.

(l) Cans have been dented by rough treatment in filled carton handling systems which permit filled cartons to collide in chutes, twists, drops, etc.

It is to be hoped that all such conditions do not exist in one factory, but each of the points brought out have been observed in some plant. However, combinations of several of the hazardous conditions have been noted. The dents or deformations may not be severe enough to be noticed particularly, but nevertheless, the disturbance at the area may have been sufficient to break the hermetic seal and permit the relatively high internal vacuum to suck in some of the water clinging to the seams.

Factors in Spoilage

The three main factors in spoilage resulting from rough handling are:

1. The condition of the can double seams.

2. Poor operation or poor adaptation of the automatic filled-can handling equipment.

3. The presence of cooling water highly contaminated with the proper types of microorganisms.

The quality of the double seam structure may vary slightly. Any slight abnormalities in the double seam are magnified by rough treatment in the presence of contaminated cooling water. Cans which might be satisfactory under ordinary conditions may show a considerable number of failures under adverse conditions.

Automatic filled-can handling equipment is a forward step in modern cannery practice. It is just as liable to get out of adjustment as a closing machine, or for that matter, as a motor car. When operating properly and efficiently, it is an asset. When not operating properly, it may become a liability.

Contaminated cooling water is more prevalent than one might suspect. Proper cooling water control, especially in canals and recirculating systems, is necessary to prevent bacterial build-up. Large supplies of fresh water, exclusion of extraneous organic material, temperature control and controlled chlorination, when advisable, will provide conditions in cooling water which will afford a minimum possibility of resultant spoilage even if some latitude exists in proper seam formation and/or in the automatic filled-can handling equipment. This is not meant to imply in the least that chlorinated cooling water will allow for poor can structure or assembly or will offset any rough treatment of cans. It does mean, however, that if every effort is made by the management to provide the best seam structure possible and to make every effort to insure that abuse of cans is eliminated by proper selection and proper operation of automatic handling equipment, highly contaminated cooling water will be less likely to offset the gains made.

In reviewing the points covered in this consideration of the relationship of spoilage to rough handling in the presence of contaminated cooling water, certain facts are evident. These are summarized:

1. Spoilage, in general, has increased where automatic filled-can handling systems have replaced hand casing directly from crates.

2. Rough handling of cans is especially dangerous when the cans are wet with highly contaminated cooling water.

3. Many installations of automatic filled-can handling equipment are improperly adapted for the purpose intended.

4. Many automatic filled-can handling units are not properly adjusted to minimize can abuse.

5. Automatic filled-can handling equipment is and has been essential to the production of canned foods and as such will continue to be used.

6. Every attempt should be made by all concerned to minimize spoilage through proper adjustment of seams, elimination of all possibilities of can abuse from automatic lines and, where advisable, controlling the bacterial count of cooling water by chlorination.

National Canners Association—Can Manufacturers Institute Nutrition Program

1. Background

By R. W. Pilcher and B. S. Clark, Research Division, American Can Company

CANNING PROBLEMS CONFERENCE

During the latter half of the 19th century, research in nutrition was one of the specialized fields of physiology and medicine. By 1890, it was common belief that human nutritive requirements could be met by a diet which included specified amounts of protein, fat, carbohydrates and minerals. At the turn of the century, however, the results of animal experimentation gave reason to question whether the above nutrients, together with water, met all of the requirements of the animal organism throughout the various phases of the life cycle. This doubt was clearly expressed by Hopkins in his famous pronouncement in 1906 which is regarded by some historians not only as the first studied prediction of the existence of the vitamins but also as the beginning of the modern era of the science of nutrition.

A few years later, Funk announced the existence of a "vital amine" now identified as thiamine. The older work of Eijkmann on the same factor was rediscovered or given new significance and by 1920 American scientists had taken a commanding position in the field of nutrition through the fundamental reasearches of Osborne and Mendel, McCollum and Davis and others. Today it appears that the list of factors essential in human nutrition includes some 50 specific nutrients.

Progress in Canning Technology

During the past four decades considerable progress was also made in the fields of can manufacture and canning technology. The modern or sanitary style of can displaced the old hole and cap type as a container for fruits and vegetables; corrosion-resistant cold reduced tin plate was developed;[1] improved machinery increased the speed and effectiveness of can manufacture and can closure; and a variety of inside can enamels and enamel systems for specific products was evolved. Likewise, in this same span of years the National Canners Association and its laboratory were

founded; thermal processing of canned foods was established on a scientific basis; and steady improvement made in canning equipment. Further, new products were developed, particularly those of the formulated and beverage types; production of standard canned food commodities was increased; new methods of processing evolved and placed in practical operation;[3] and official regulations developed which served to raise the quality level of many commercially canned foods.

While over-all canned food production for civilian consumption reached its highest peak in history during the year before Pearl Harbor, by 1923, when the use of the sanitary can had become well-nigh universal, canned foods had already assumed a highly important role in nutrition of the American people. This fact is apparent from available production statistics for that period.

Early Nutrition Studies on Canned Foods

Kohman has reviewed the early nutrition studies on canned foods in his excellent treatise on the subject.[3] The laboratory of the National Canners Association had watched with interest the early expanding activities in the field of nutrition and in 1922 issued the first edition of N.C.A. Bulletin 19-L which summarized knowledge existing at that time on vitamins in canned foods.

By 1923, the existence of three of the essential vitamins had been established; preliminary evidence had also been adduced as to the existence of several others. At that time, there was also apparent a definite trend in nutrition research toward the establishment both of vitamin values of specific foods and the stability of the vitamins in foods. Decision was therefore made to institute nutrition studies on canned foods. The end result of this decision was the inauguration of the well known collaborative program between the National Canners Association and Teachers College, Columbia University, carried out by Kohman, Eddy and their associates. The results of the studies as well as related studies in the field have been discussed by Kohman.[3]

The Period 1924 to 1942

After their first report on vitamin C in apples in 1924, Kohman, Eddy and their associates extended their work to vitamin studies on spinach, peas, peaches, strawberries, pears and tomato products. After 1930, using the improved vitamin assay methods of that period canned products such as prunes, grapefruit, tomato juice and turnip greens were also included up to the time the program terminated in 1937. Meanwhile, as indicated by Kohman,[3] other workers became active in the field and the findings of Kohman and Eddy were supplemented by those of other investigators. As the store of available information on vitamin stabilities and vitamin contents of all types of foods—canned foods included—increased, summaries on the effects of processing on vitamins began to appear.[4, 5]

Further, for many years, beginning with the early tables on food composition compiled by Atwater and Bryant in 1906, the U. S. Department of Agriculture had sought to facilitate practical application of research findings on foods by the periodic issuing of bulletins which served to summarize knowledge. In 1937 and in 1942 two comprehensive bulletins of this type were published which found nationwide use by students of nutrition, home economics, dietitians, instructors and other professional people engaged in diet planning or formulation.[6, 7] In this same period, the Food and Nutrition Board of the National Research Council issued the first of its present series of recommended daily allowances of cetrain nutrients, including four of the vitamins.[8]

Inspection of these publications will reveal, despite the amount of attention accorded vitamins in canned foods prior to 1942, that relatively few of the data could be given quantitative expression. This fact had also come to light in the course of preparation of texts devoted specifically to commercially canned foods.[9, 10]

The National Nutrition Conference

While these facts were well known to technical persons in the industry, it remained for the National Nutrition Conference for Defense, called by President Roosevelt in May, 1941, to supply the major impetus for inauguration of the present nutrition studies on canned foods. This meeting was liberally attended by members of the canning and can manufacturing industries. Transactions at the conference highlighted the need for more data on the nutritive values of canned foods and emphasized the paucity of existing information.

This need was discussed in the Research Committee of the National Canners Association; the cooperation of the Can Manufacturers Institute was solicited and obtained; funds to support one year's study were assured; and a special committee created to recommend not only a plan of experiment for the proposed program, but equally important, a means of administration. During the summer and fall of 1941 this committee explored what appeared to be the major possibilities. As more fully discussed later, agreement was readily reached as to the possible experimental pattern of the program; selection of the means of administration proved to be the more vexatious problem.

Administrative Plan

As far as administration was concerned, in planning for the program several options immediately presented themselves. The first of these considered was the possibility that some existing, recognized agency with known interest in public health would undertake sponsorship of the program. This possibility was investigated but it soon became apparent that no such agency possessed the necessary organization to handle the scope of the work projected even for the first year of study. The second option to receive serious consideration was the establishment of a foundation under the leadership of a recognized student of nutrition which would be affiliated with some recognized educational institution. This foundation, it was proposed, would undertake the work not only with its own personnel, but also through a series of research grants or grants-in-aid to other institutions. This system of administration had a record of success in the past and offered definite advantages in guiding research over a long period of time. However, due to the uncertainty existing at the time as to the future course of the program, this possibility was not considered practical under existing circumstances. A third means of administration, considered and abandoned, was the assignment of some qualified person connected with the industry to full time management of the program. Finally, in January, 1942, decision was reached to place guidance of the program under an executive committee composed of technical representatives of the two sponsoring bodies and this plan of administration has been followed throughout the program.

Since its inception, the executive committee has had full responsibility for the planning and execution of all projects undertaken during the past four years of operation. The personnel of the committee numbers five, including three representatives of the National Canners Association and two of the Can Manufacturers Institute. The Committee is under the chairmanship of Dr. Edwin J. Cameron, Director of the Association's Washington Laboratory; his Administrative Assistant, Mrs. Kathryn L. Monroe, has also served the Committee in the keeping of records and in the correlation of the many diverse activities now involved in the program.

During the first year of operation, it became apparent that the Executive Committee frequently required assistance on matters of broad policy or procedure, or on other special problems. To provide this assistance, two additional committees composed of persons in the canning and can manufacturing industries were created, namely, the Industry Advisory and Special Advisory Committees. The Executive Committee convenes about twice a year; the advisory committees meet with the Executive Committee only as circumstances may require. A second need also became evident after the first year's experience, namely, for some type of authority to operate in the interim between Executive Committee meetings. The work of the program is national in scope; frequently local problems arise which re-

quire prompt decisions or changes in initial planning. Further, as the work developed the number of necessary contacts became quite large. To meet this need, a system of regional committees was created known as the Western, Central and Eastern Regional Committees, each under the chairmanship of a member of the Executive Committee and each composed of individuals associated with the canning or can making industries. In the interim periods these committees handle all matters relative to the program which may arise in their respective localities; they also serve as the focal points of all contacts with collaborating institutions within their geographic jurisdictions.

Pattern of the Nutrition Program

In considering the type and scope of the work to be undertaken in the first year of operation, it appeared that the work to be done fell into several distinct categories or phases:

1. Determination of the specific influences or effects of commercial canning operations or common practices on the nutrients in raw canning stocks with the ultimate purpose of improving retention of such nutrients in the final product. This phase also includes other studies of a specialized type related to improvement of the nutritive values of canned foods.

2. Establishment of the nutritive values of foods canned by modern practices with respect to their contributions of vitamins, minerals and the proximate food components such as fat, carbohydrate and protein.

3. Increase in existing knowledge of the physiologic utilization of canned foods and their values under various conditions of human nutrition.

These respective phases of the work are listed in the order in which they preferably would be undertaken under normal circumstances and under the most favorable conditions of time and personnel. However, as has been indicated, the planning of the program was carried out in the periods shortly before and shortly after Pearl Harbor and the urgent needs of those agencies charged with proper nutrition of the armed forces had to be given first consideration. Specifically, there was a demand for more exhaustive information on the composition of all types of foods, particularly with reference to their vitamin values. So important was this need that in 1941 the National Research Council appointed a Food Composition Committee to compile and tabulate information on the subject from all possible sources and especially data previously unreported by industry. Therefore, in the first year of operation emphasis was placed on the establishment of the nutritive values of canned foods as then manufactured in deference to the current and pressing need. This type of activity has been designated as Phase I. After examining the results of the first year's work, the sponsoring bodies approved continuation of the program. It then became possible during the second year to undertake what are now known as Phase II studies, namely, determination of the specific effects of canning operations or practices on the nutrients in raw foods and study of ways and means of improving retention to a greater degree of these essential factors. The program is now in its fourth year of operation and Phase II activities currently constitute the major portion of the projects in progress.

After three years' experience, most of which was under wartime conditions, the Executive Committee is inclined to defer as of lesser importance the third type of activity listed above, or Phase III, and to concentrate on the many problems which have arisen as a result of the Phase II studies. While retentions of nutrients in many instances are quite satisfactory, there is ample evidence that modifications in certain operations, notably in blanching, would markedly increase the retention in other specific instances. Such modifications, involving as they well might both equipment and quality of the final product, have distinct economic implications and must be carefully and painstakingly explored. For these reasons, it is felt that available funds and talent had best be diverted first to investigations of the Phase II type of study and to repetition of Phase I at some future date after the findings in Phase II studies have found practical application.

Execution of Experimental Projects

In the initial planning, the guiding policy was laid down that in so far as possible the actual experimentation should lie in the hands of competent, disinterested institutions well known for their works in the field of nutrition. This was considered particularly important in the case of the Phase I studies because of the probable use of the data obtained by nutritionists. Likewise, it was considered advisable that the initial exploration in Phase II should be left in the hands of some university collaborator. Consequently, the first task of the Executive Committee in setting up the program was to allocate the problems on hand to various institutions through the medium of research grants. Fortunately, as will be described in a later paper in this series, the type of work involved in the program as well as the objectives of the program itself proved attractive to a number of outstanding colleges and universities and their collaboration was secured.

However, in subsequent years many institutions suffered shortages of personnel due to the operations of Selective Service. In the second year and since it has not been possible to conclude arrangements with a sufficient number of institutions to handle the volume of work which must be undertaken. It has consequently been necessary for the laboratories of the National Canners Association to assume study of certain of the Phase II problems, particularly where some knowledge of canning technology is desirable for most effective performance of the work. The results achieved in the program to date will be covered by a later paper in this series.

Acknowledgment

Response to the program—with respect both to its findings and objectives—in the field of nutrition has been gratifying to the Executive Committee. However, no general discussion of the pattern, administration and findings of this program would be complete without acknowledgment of the helpful assistance of the Industry and Special Advisory Committees as well as the many other individuals in various branches of the services, universities and colleges, and Federal laboratories whose help has been sought from time to time and freely given. Any success which this program may ultimately attain will in no small part be due to the thoughtful consideration which such individuals have given to many of the problems involved.

2. Progress

By L. E. Clifcorn, Director, Product and Process Research Division, Continental Can Co.

In this discussion of the progress of our Nutrition Program, in accordance with the organization and planning which has been described by Dr. Pilcher, I will attempt to discuss in broad aspect the work which has been completed to date, the results found, and to a limited extent, the significance of the findings.

From the standpoint of thoroughness and completeness, our Phase I work [11,12,13,14] has resulted in tables of canned food composition which excel those for any other class of foods. The two years' survey by five universities has included the analysis of 1,309 samples of 43 canned food products for the vitamins, ascorbic acid, carotene, thiamine, riboflavin, niacin, and pantothenic acid; the minerals, calcium, phosphorus, and iron; and proximate composition.

Products Assayed

Apricots, unpeeled halves
Asparagus, all green
Asparagus, culturally bleached
Beans, baked, New England style
Beans, with tomato sauce
Beans, green cut
Beans, lima, green
Beets
Blackberries
Blueberries
Carrots
Cherries
Corn, white, whole kernel
Corn, yellow, whole kernel
Corn, white, cream style
Corn, yellow, cream style
Grapefruit juice
Grapefruit segments
Kraut
Mackerel
Mushrooms
Orange juice
Peaches, clingstone, halves
Peaches, freestone, halves
Pears, halves

Products Assayed—Continued

Peas, Alaska	Sardines, in oil
Peas, sweet (wrinkled varieties)	Sardines, in tomato sauce
Peppers, sweet, red	Shrimp, dry pack
Pimientoes	Shrimp, wet pack
Pineapple juice	Spinach
Pineapple, sliced	Tomatoes
Potatoes, sweet	Tomato juice
Prunes, Italian	Tuna
Salmon	Turnip greens

In addition, some of the newer vitamin B factors, biotin, folic acid, and pyridoxine, have been determined on ten of the products in which they might be expected to be present in significant quantities.

During the period of the War, we answered the need for more extensive and accurate information on the nutritive qualities of canned foods, which was needed for Army feeding and Lend-lease purposes. Information has also been supplied to help in the intelligent planning of human dietaries. We now know which canned foods are excellent, good, fair and poor sources of the specific nutritive factors. The contributions of canned foods to the human nutritional requirements can now be evaluated as shown in Table I.

in the raw products, the canned products have been found to be excellent or good sources. The error must not be made of comparing the vitamin content of canned foods with that of uncooked "fresh foods". Some sacrifices are made in vitamin content in canning due to heat, oxidation and extraction, the same as in cooking. These will be discussed further.

Since the methods of vitamin analysis employed determine the reliability of the results obtained, the vitamin methods selected for this work were correlated with other existing methods on carefully prepared samples of canned carrots, corn, peas, tomatoes, and salmon.[11] This work was conducted at Pennsylvania State College and has recently been published. The results speak well for the vitamin methods which have been used in our work, and strongly emphasize the importance of work on such methods for a wide variety of canned food products.

The distribution of water soluble vitamins and minerals between the solid and liquid portions of the can has been an important consideration upon which work has been conducted at the University of Chicago and the University of Maryland.[13, 14] With regard to the water soluble vitamins, Table II shows that the distribution generally follows the distribution of water in the can, approximately two-thirds in the solid and one-third in the liquid.

Since the vitamin content of canned foods at the time they are eaten is the most important consideration from the consumer standpoint, work was sponsored on the effect of preparation for serving at the University of Chicago.[16,17] Home preparation methods using consumer size cans and institutional preparation using several No. 10 cans were studied.

In home preparation, two methods of cooking were employed, (1) heating the total contents of the can to a boil and serving solids only, and (2) boiling the liquid portion to one-half to one-fourth the original volume, adding the solids, bringing to a boil and serving the entire contents. In institutional preparation, the methods were guided mainly by Army and Navy interest. The total contents of several No. 10 cans were boiled for thirty minutes, after which two methods of serving were employed, (1) serving with all the liquid and (2) serving solids with a slitted spoon. The results of this investigation are shown in Table III. In addition, in the large scale method, holding on a steam table for one and one-half hours was studied with the result that some losses were observed in ascorbic acid content, but little in thiamine and riboflavin content.

The Phase II work of our Nutrition Program has been defined as a study of the effects of canning operations on the vitamin content of raw food products with the ultimate objective being to determine the over-all losses during canning operations, the specific stations at which serious losses take place, and correction of such losses, preferably by changes in the operation of existing equipment or possibly by recommendations of principles for better equipment. In this work it is imperative that the quality of the canned food products be maintained or improved by any changes resulting in higher vitamin content. The first step in this work has been a very extensive survey of canning operations.

Studies have been carried out at Pennsylvania State College, the University of Wisconsin, and the West Coast Branch of the National Canners Association to determine the overall losses and the losses at specific stations during the canning. To date the West Coast Laboratory of the National Canners Association has conducted such surveys in sixty-four canneries on sixteen different products, with consideration to the vitamins, ascorbic acid, carotene, thiamine, riboflavin, and niacin. In most canneries, four to six independent runs were made. Similar surveys, less extensive in nature, were made by the two universities mentioned cooperating in this phase of the work. Special attention has been given to certain operations which have been found to materially affect the vitamin content, such as lye peeling, holding of the raw products prior to canning, types of blanchers, times and temperatures of blanching, storage of some blanched products before filling, and processing.

Table IV shows the retention of ascorbic acid, thiamine and riboflavin during the commercial canning of No. 3 and No. 4 sieve size Alaska peas.[20] It will be observed that there is a significant decrease of ascorbic acid during blanching, with a less significant decrease for the other two vitamins, thiamine and riboflavin. This loss is due mainly to the extraction of these water soluble vitamins from the peas. It will also be observed that there is a significant decrease in thiamine con-

Table 1

CONTRIBUTION OF ASCORBIC ACID, CAROTENE AND THIAMINE BY FOUR-OUNCE SERVING OF CANNED FOOD IN DAILY ADULT DIET

Products	Ascorbic acid: Average content Mg/100	Ascorbic acid: Percent Supplied Recommended[1]	Ascorbic acid: Percent Supplied Minimum[2]	Carotene: Average content Mg/100	Carotene: Percent Supplied Recommended	Carotene: Percent Supplied Minimum	Thiamine: Average content Mg/100	Thiamine: Percent Supplied Recommended	Thiamine: Percent Supplied Minimum
Asparagus, all green	15.3	22.8	57.0	.36	13.3	16.6	.064	4.8	7.2
Beans, green cut	3.3	4.9	12.3	.18	6.7	8.4	.029	2.1	3.2
Beets	3.0	4.5	11.3	.074	2.7	3.4	.008	0.6	.9
Carrots	2.0	2.9	7.3	7.34	274.0	342.0	.021	1.6	2.4
Corn, yellow, w.k.	4.5	6.7	16.8	.085	3.33	4.16	.026	1.9	2.9
Grapefruit juice	33.1	49.5	123.8	.007	.27	.34	.028	2.1	3.1
Kraut	17.3	25.9	64.8	.031	1.17	1.46	.034	2.5	3.8
Orange juice	35.1	52.4	131.0	.096	3.67	4.59	.073	5.5	8.2
Peaches, halves, clingstone	3.8	5.7	14.3	.26	9.67	12.1	.007	.5	.8
Peas, sweet	9.2	13.7	34.3	.26	9.67	12.1	.112	8.3	12.5
Potatoes, sweet	16.2	37.9	94.8	5.94	221.0	276.0	.053	3.9	5.9
Pineapple juice	8.5	12.7	31.7	.03	1.0	1.3	.052	3.9	5.8
Spinach	13.1	19.6	49.0	3.29	122.0	153.0	.019	1.4	2.1
Tomatoes	17.0	25.3	63.3	.58	21.7	27.1	.054	4.0	6.0

[1] National Research Council. [2] Food and Drug Administration.

The question is often asked, "How do I know the vitamin content of a single can of peas for example?" The answer is that this information can only be determined by analysis, but in all probability, the vitamin content falls within the ranges and close to the average values which have been found. This becomes more true when more cans are considered, particularly when from different sources.

It is obvious that products which are naturally low in certain vitamins in the raw state cannot be improved in this regard by canning. For example, the fruit products, with the exception of thiamine in orange juice, are generally looked upon to be low in the B vitamins and show up similarly when canned. Where significant quantities of certain vitamins are present

Table II

DISTRIBUTION OF WATER SOLUBLE VITAMINS IN CONSUMER SIZE CANS OF VEGETABLES

Vegetable	No. of Experiments		Weight: Total per can Gm	Weight: Distribution Percent	Ascorbic Acid: Concentration Mg/100gm	Ascorbic Acid: Distribution Percent	Thiamine: Concentration Mg/100gm	Thiamine: Distribution Percent	Riboflavin: Concentration Mg/100gm	Riboflavin: Distribution Percent
Asparagus, all green	1	solid	359	62	6318.4	60	23.335	62	44.516	71
		liquid	222	38	4262.4	40	14.430	38	17.982	29
Beans, green cut	5	solid	375	64	2028.75	64	13.500	67	20.250	76
		liquid	212	36	1174.48	36	6.784	33	6.360	24
Beans, green lima	4	solid	411	70	2429.01	56	11.508	68	22.194	76
		liquid	178	30	1833.4	44	5.340	32	6.942	24
Carrots	1	solid	378	64	963.9	66	8.316	66	7.938	74
		liquid	216	36	425.52	34	4.320	34	2.808	26
Corn, white whole kernel	1	solid	392	67	1513.12	48	5.880	67	12.152	80
		liquid	191	33	1631.14	52	2.865	33	4.966	20
Corn, yellow whole kernel	4	solid	405	68	2101.95	61	13.770	67	25.515	78
		liquid	186	32	1335.48	39	6.510	33	6.696	22
Peas, sweet wrinkled varieties	4	solid	393	66	3654.9	63	47.160	66	25.545	70
		liquid	203	34	2151.8	37	24.563	34	10.962	30
Spinach	2	solid	495	63	2935.35	62	6.435	69	39.600	76
		liquid	296	37	1820.4	38	4.144	31	12.432	24

tent upon processing due to the instability of this vitamin to heat.

Table No. V shows the retention of ascorbic acid, thiamine, riboflavin, and niacin during the commercial canning of lima beans, No. 3 and No. 5 sieve sizes.[34] Here again we have a significant loss of ascorbic acid, and the other water soluble vitamins upon blanching and a significant loss of thiamine upon processing. Similar to the greater solubility loss of the water soluble vitamins in the smaller sieve sizes of peas, we find a greater loss in blanching of the No. 3 sieve size lima beans as compared to the No. 5 sieve size.

Table No. VI [34] shows the retention of ascorbic acid, thiamine, riboflavin, and niacin in commercially canned yellow whole kernel corn. The most significant losses were those during processing for thiamine, which is explained by the severe heat treatment used for sterilizing this product.

Surveys were also carried out on the effect of canning on the ascorbic acid content of grapefruit juice, Table VII.[34] As a result of several runs in a total of ten different canneries, over 92 percent retention of ascorbic acid was obtained in all. Our surveys have shown that there is no particular problem with regard to the retention of ascorbic acid during the canning of the citrus juices.

With regard to the preparation and canning of tomato juice excessive losses of ascorbic acid have been noted in many instances, due mainly to incorporation of excessive amounts of air, the lack of rapid handling of the juice after extraction and, in some instances, the use of too much copper equipment. The research laboratories within the industry, as a result of considerable work, are now in a position to recommend practices for greater ascorbic acid retention in this product.

Since blanching seems to be the station at which it may be possible to correct the greatest losses of vitamin content during the canning of vegetables, grants have been established at the University of Wisconsin and at

Table III

PERCENT RETENTION OF VITAMINS AFTER PREPARATION FOR SERVING

(Original Canned Product—100 Percent)

	Home preparation						Institutional preparation (boiled 30′)					
	Liquid concentrated			Liquid discarded			Solids and liquids			Drained solids		
Vegetable	Ascorbic acid	Thiamine	Riboflavin	Ascorbic acid	Thiamine	Riboflavin	Ascorbic acid	Thiamine	Riboflavin	Ascorbic acid	Thiamine	Riboflavin
Asparagus	..	..	..	..	..	..	95	95	100	72	72	76
Beans, baked	..	..	..	..	..	..	..	90	85	..	..	..
Beans, cut green	81	98	100	49	61	65	53	92	100	30	60	70
Beans, green lima	62	97	93	39	62	71	45	94	90	29	73	72
Carrots	41	96	100	..	..	..	40	95	98	72	74	80
Corn, yellow, w.k.	50	92	98	37	..	63	32	78	98	7	57	70
Peas	51	100	100	30	63	65	..	..	..	..	..	..
Spinach	..	..	..	38	72	69	77	96	96	52	67	69
	Heated—All served						Boiled 30 mins.					
Tomatoes	97	100	100				97	83	100			

Table IV

RETENTION OF ASCORBIC ACID, THIAMINE, RIBOFLAVIN IN COMMERCIALLY CANNED PEAS

Sampling station	Mg/100 gm dry wt.: Ascorbic acid	Mg/100 gm dry wt.: Thiamine[1]	Mg/100 gm dry wt.: Riboflavin	Percent retained: Ascorbic acid	Percent retained: Thiamine[1]	Percent retained: Riboflavin
Cannery No. 3, Alaska peas, No. 2 cans:						
Raw ungraded	136.7	1.10	0.47	...	...	...
No. 3 sieve—raw	122.0	1.23	0.53	100	100	100
No. 3 sieve—blanched (3′ @ 190-200°F.)	....	1.08	0.42	...	88	79
No. 3 sieve—blanched (3′ @ 170°F.)	79.7	....	....	65	...	...
No. 3 sieve—filled (no brine)	88.8	0.94	0.38	73	76	72
No. 3 sieve—processed (25′ @ 245°F.)	88.8	0.62	0.39	73	50	73
No. 4 sieve—raw	93.7	1.06	0.45	100	100	100
No. 4 sieve—blanched (3′ @ 190-200°F.)	74.2	0.98	0.33	79	92	73
No. 4 sieve—filled	69.8	0.88	0.30	74	83	67
No. 4 sieve—processed (25′ @ 245°F.)	69.8	0.66	0.30	74	62	67

[1] Expressed as thiamine hydrochloride.

Table V

RETENTION OF ASCORBIC ACID, THIAMINE, RIBOFLAVIN, AND NIACIN IN COMMERCIALLY CANNED LIMA BEANS

Sampling station	Ascorbic acid	Thiamine[1]	Ribo flavin	Niacin
	Mg/100 gm dry wt.			
Cannery No. 18, No. 2 cans:				
Ungraded—washed	56.0	1.24	0.30	3.99
No. 3 sieve—inspected	73.7	0.65	0.40	4.05
No. 3 sieve—blanched (4′ @ 190°F.)	40.2	0.38	0.29	2.82
No. 3 sieve—filled, closed, brined	52.7	0.38	0.30	3.28
No. 3 sieve—processing (35′ @ 240°F.)	50.7	0.31	0.30	3.05
No. 5 sieve—inspected	46.3	0.48	0.33	3.47
No. 5 sieve—blanched (4′ @ 190°F.)	33.9	0.37	0.24	3.39
No. 5 sieve—filled, closed, brined	33.5	0.37	0.25	3.37
No. 5 sieve—processed (35′ @ 240°F.)	33.5	0.28	0.24	3.25
	Percent retained			
No. 3 sieve—inspected	100	100	100	100
No. 3 sieve—blanched (4′ @ 190°F.)	54	58	73	70
No. 3 sieve—filled, closed, brined	71	58	74	81
No. 3 sieve—processed (35′ @ 240°F.)	69	48	75	75
No. 5 sieve—inspected	100	100	100	100
No. 5 sieve—blanched (4′ @ 190°F.)	73	77	73	98
No. 5 sieve—filled, closed, brined	72	77	76	97
No. 5 sieve—processed (35′ @ 240°F.)	72	58	73	94

[1] Expressed as thiamine hydrochloride.

Table VI

RETENTION OF ASCORBIC ACID, THIAMINE, RIBOFLAVIN, AND NIACIN IN COMMERCIALLY CANNED YELLOW WHOLE KERNEL CORN

Sampling station	Mg/100 gm dry wt. Ascorbic acid	Thiamine[1]	Riboflavin	Niacin	Percent retained Ascorbic acid	Thiamine	Riboflavin	Niacin
Cannery No. 14, No. 2 cans:								
From cutter	41.7	0.47	0.42	5.78	100	100	100	100
From cleaner	39.1	0.49	0.39	5.82	94	105	93	101
Filled and brined[2]	34.0	0.43	0.39	5.24	82	91	93	91
Processed (55′ @ 240°F.)	38.4	0.15	0.38	5.00	92	32	91	86
No. 10 cans:								
From cutter	45.2	0.60	0.53	5.35	100	100	100	100
From cleaner	42.2	0.56	0.48	5.43	93	93	91	101
Filled and brined[2]	32.3	0.50	0.50	4.93	71	84	94	92
Exhausted	29.7	0.56	0.37	5.35	66	93	70	96
Processed (90′ @ 240°F.)	39.4	0.19	0.35	4.80	87	32	66	90

[1] Expressed as thiamine hydrochloride.
[2] Hydraulic lift employed using hot water. Equivalent blanch 1/4′ @ 130–140°F.

Table VII

EFFECT OF CANNING ON ASCORBIC ACID CONTENT OF TEXAS GRAPEFRUIT JUICE

Plant	Extractors mg/100 ml	After screening[2] mg/100 ml	At holding tank mg/100 ml	At holding tank Percent of original	At filler bowl mg/100 ml	At filler bowl Percent of original	Canned juice mg/100 ml	Canned juice Percent of original
1	42.2	41.4	41.7	100.7	42.4	102.3	41.1	99.4
2	48.5	51.3	50.5	98.4	47.2	92.1	49.7	96.9
3	42.8	44.8	41.6[1]	93.1	41.1	91.8	41.3	92.2
4	42.0	43.1	42.4	98.2	41.4	95.6	40.5	94.0
5	37.1	38.7	38.7	100.0	36.5	94.3	36.7	94.8
6	38.2	37.8	....	....	37.9	100.2	37.2	98.4
7	40.7	39.5	39.7	100.3	38.4	97.2	38.4	97.2
8	39.5	40.6	41.0	101.0	39.0	96.0	38.8	95.6
9	37.6	38.1	....	....	37.0	97.0	37.1	97.4
10	42.1	42.3	41.2	97.3	40.0	94.9	40.0	94.6
Av.	....	....	....	98.6	....	96.3	....	96.1

[1] Freshly pasteurized—held in holding tank after pasteurization.
[2] These values used as basis for retention calculations.

Table VIII

EFFECTS OF VARIATIONS IN PRODUCT AND BLANCH ON VITAMIN RETENTION IN GREEN BEANS

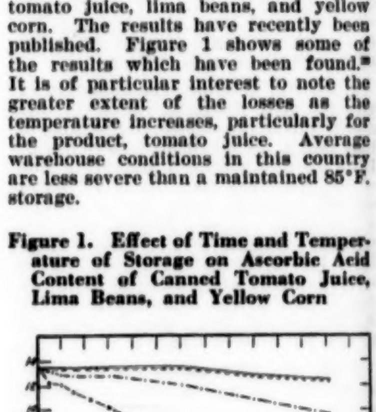
Description	Ascorbic acid mg/100 g	Percent retained Bl.[2]	Pr.[3]	Thiamine[1] mg/100 g	Percent retained Bl.[2]	Pr.[3]	Niacin mg/100 g	Percent retained Bl.[2]	Pr.[3]
Raw, whole, No. 3 sieve	140.0	..	..	0.99	..	..	4.57	..	..
Blanched, 2′ at 160° F.	.....	..	35	....	97	62	....	96	103
Blanched, 2′ at 210° F.	.....	77	53	....	95	59	....	97	89
Blanched, 6′ at 160° F.	.....	41	32	....	98	65	....	96	73
Blanched, 6′ at 210° F.	.....	60	45	....	95	51	....	89	73
Raw, whole, No. 3 sieve	129.0	..	..	0.99	..	..	4.83	..	..
Blanched, 2′ at 160° F.	.....	35	..	....	93	..	....	97	..
Blanched, 2′ at 185° F.	.....	98	..	....	90	..	....	102	..
Raw, cut, No. 4 sieve	155.0	..	..	0.95	..	..	4.95	..	..
Blanched, 2′ at 160° F.	.....	44	44	....	96	66	....	106	99
Blanched, 2′ at 210° F.	.....	69	45	....	95	42	....	98	95
Blanched, 6′ at 160° F.	.....	57	36	....	105	58	....	109	98
Blanched, 6′ at 210° F.	.....	74	44	....	96	51	....	89	104

[1] Expressed as thiamine hydrochloride. [2] Bl–Blanched. [3] Pr–Processed.

Pennsylvania State College for specifically studying blanching. It was believed that more specific information should be obtained on the variables entering into this problem, such as the effect of time, of temperature, of large or small volumes of blanching water, of steam blanching, of accumulation of water soluble vitamins in the blanch water, and so forth. Thus far work conducted along these lines looks very promising, and when this work is completed, we believe that recommendations for the operation of hot water blanchers for the retention of more water soluble vitamins with the same or improved quality will be forthcoming, for many of the vegetable products. As an example, we have in Table VIII[26] the results of a study of the effect of blanching under various times and temperatures on the vitamin content of green beans. It will be observed that for this particular product, temperature has been found to be a more important factor than time, since at both the two minute and six minute blanches at 210°F. greater retention of ascorbic acid has been obtained than at the lower temperatures. This finding has been confirmed by results from the West Coast National Canners Association and is somewhat contradictory to the findings in general, which show time to be a more significant factor than temperature.

The effect of storage on the vitamin content of canned foods was started early in this program by establishing a grant for this purpose at Pennsylvania State College. In addition to the temperatures, 30°, 42°, and 85°F., the temperature 110°F. was added, particularly because of Army interest in the storage of canned foods in subtropical areas. It was known that losses of several of the important vitamins in canned foods took place upon storage in direct proportion to the temperature and length of time of storage. The extent of these losses under constant temperature conditions was determined for the products, tomato juice, lima beans, and yellow corn. The results have recently been published. Figure 1 shows some of the results which have been found.[9] It is of particular interest to note the greater extent of the losses as the temperature increases, particularly for the product, tomato juice. Average warehouse conditions in this country are less severe than a maintained 85°F. storage.

Figure 1. Effect of Time and Temperature of Storage on Ascorbic Acid Content of Canned Tomato Juice, Lima Beans, and Yellow Corn



Further studies on the storage effect on vitamins is in progress upon a wide number of canned food products being stored at the maintained temperatures of 50°, 65°, and 80°F. Pennsylvania State College is studying the non-acid products and the University of Chicago the acid products. Samples are being removed at periodic intervals and analyzed for the vitamins of importance.

The question has arisen as to the storage temperatures existing in the commercial warehousing of canned foods. In order to obtain more information on this, surveys are being con-

ducted of the daily maximum and minimum temperatures of eighty warehouses throughout the country. From this information one should be able to extrapolate the storage effect for the average storage temperature of a given warehouse from the data which are being obtained at maintained constant temperatures. In addition, lots of canned tomatoes, peas, and orange juice have been stored in nine warehouses throughout the country from the same lots of material being stored at the Universities under maintained constant temperatures. From the daily maximum-minimum temperature records for the warehouse storage of these products, we will be able to determine definitely whether a correlation such as mentioned above can accurately be made.

As originally outlined, the Phase III work covering the tests on the significance of canned foods in animal and human diets was tentatively planned. A thorough investigation of the merits of conducting this work has been made, with the result that it has been decided to postpone such investigations indefinitely. There is considerable question as to what would be gained by such work in consideration of the very high expenditures involved.

In conclusion I wish to say that the canning industry has conducted a Nutrition Program with progress such that it is a challenge to all other food processors. The following has been accomplished:

1. A survey of the nutritive qualities of non-formulated canned foods.

2. A correlation of rapid methods of vitamin assay with other recognized methods.

3. Determination of the distribution of vitamins, minerals, and other food factors between the solid and liquid portions of the can.

4. A study of the effects of preparation for serving on vitamin content, as applied to home and large scale uses.

5. A survey of the effects of canning operations on the vitamin content of vegetables and fruits.

6. A study of the effects of some relationships of time and temperature of blanching on the vitamin content of certain vegetables.

7. A study of the effect of storage at different maintained constant temperatures on vitamin content.

8. A survey of the temperature conditions of eighty warehouses throughout the country.

9. Definite progress on the greater retention of vitamins in some products. Although it is very true that consumers in most instances do not buy canned foods for their nutritional qualities, those who are in a position to evaluate the nutritional merits of foods and recommend their use, speak highly of canned foods because of the aggressive manner in which we have attacked the problem before us. The amount of work involved is tremendous in scope and our appreciation should be given to the vitamin and nutritional authorities and their co-workers who have heartily cooperated with us. In many instances, the work was not of the type that they would most desire to conduct, but they have appreciated our problem. They knew that sound research on the nutritive aspects of canned foods would be constructive to the interests of both the canners and the consumers.

3. Objectives

By J. Russell Esty, Director, N. C. A. Western Branch Research Laboratory

Under the direction of the Executive Nutrition Committee there is a Publications Committee, whose duty it is to review the scientific articles prepared by those conducting the research and to arrange for further use and dissemination of the technical information in order that the pertinent facts may become available to as many interested persons as possible.

The results of the so-called Phase I studies which established the nutritional values of the principal canned fruits, vegetables, and fish products as now manufactured commercially, are of particular interest to nutritionists, dietitians, home economics teachers, professional workers, and public health officials, while the Phase II, or improvement studies, designed to show how the maximum nutritive value of canned foods may be retained during canning, are of primary interest to those connected with the industry.

The first five scientific papers were published in the August, 1944, issue of the *Journal of Nutrition* and since then there have appeared in scientific journals eight more articles, all of which contain the original detailed findings of the research done by various investigators working on the joint nutrition program sponsored by the National Canners Association and the Can Manufacturers Institute. Four other articles have been accepted for publication and several others are being prepared—all of a technical nature. Work is still in progress on various subjects.

A review of the first five papers was published in *Nutrition Reviews, No. 3*, March, 1945, entitled "The Nutritive Value of Canned Foods." Reprints of this are also available upon request.

A report for the canning industry was prepared and published as a supplement to the N.C.A. INFORMATION LETTER of April 28, 1945, covering the "First Year's Findings in NCA-CMI Nutrition Program," by R. W. Pilcher.

In order to make available the results of this comprehensive research on Phase I to non-technical as well as to technically-trained persons, the Can Manufacturers Institute has prepared an interesting booklet in lay language. It is entitled "Nutrition in a Nut Shell." Upon request, copies of this may be obtained from the Can Manufacturers Institute, Inc., 60 East 42nd St., New York 17, N. Y. For several months the Can Manufacturers Institute has been carrying advertisements in medical journals and various magazines, each number featuring one or more facts disclosed by these studies. The advertisements are appearing in such publications as *Journal of Nutrition, Journal of Home Economics, What's New in Home Economics, Journal of the American Dental Association, Journal of American Medical Association, American Journal of Nursing, Public Health Nursing, etc.*

Plans are under way to prepare an N.C.A. bulletin on nutrition, in which the essential facts on Phase I will be brought together and presented in a popular manner.

Through the medium of meetings, addresses are given covering various phases of the work done and summarizing the essential findings. In these ways, the Phase I work is being publicized and becoming useful in replacing statements based upon less complete information. The present work is generally considered to be the most detailed and comprehensive of its kind.

Concerning the Phase II work, it is planned to carry on an educational program within the industry, disseminating information as it becomes available through personal contact, circulars, and articles in trade journals. In addition to recent work done on retention of food values in connection with the current research program, a great deal of similar work has been done in research laboratories of the American Can Company, Continental Can Company, and other laboratories connected with the canning industry. Some of the results have been published in technical journals and others in trade journals. As in the case of Phase I work, it is contemplated that there will be a similar NCA bulletin incorporating the essential facts from the Phase II studies in the various laboratories where the work has been done.

Another part of the educational program will be to interest canning machinery companies to conduct cooperative research with canning companies with a view to developing better mechanical means of retaining the valuable nutrients, through the application of principles established in the Phase II studies. In some cases, it may mean radical changes in the present equipment and in others a different way of doing it.

The Home Economics Division of the National Canners Association has used information published through this research program in various ways. Miss Marjorie Black, Director of the Home Economics Division, makes the

following statement* regarding the Division's use of this information:

"The facts have been used in newspaper and radio releases, and in a leaflet.

"Three different stories are written and sent to 465 food editors of newspapers each month. Three different stories are written in order that each paper in a city may receive an exclusive one.

"The radio release is sent out each month to 675 radio people, particularly to those interested in women's programs.

"The information in the releases may include recipes, information about canned foods or pertinent suggestions about their use and nutritive value. They are natural outlets for keeping important facts before homemakers.

"In 1945 a leaflet was written based on the first seven papers which had been published. It was called 'Nutritive Values of Canned Foods' and was written in simple language to be understood by anyone without technical training. It was particularly planned for grade school and high school students.

"The program for 1946 will continue the use of the nutrition information in the newspaper and radio releases. A new leaflet will be written which will condense the information in the present leaflet and will include information from all published research papers. It will be written in simple language, too, in fact all information sent out from the Home Economics Division is written in homemaker language.

"Another plan is to feature one page editorial ads in the Home Economics Magazine, 'What's New in Home Economics.' It is a magazine especially well received by teachers. The page will be devoted to an individual subject each month such as phosphorus, calcium, iron, niacin, carotene, etc. By the end of the series, each subject will have been presented. The pages in this magazine are perforated and punched to be removed easily to use in note books, and we hope that is the way the information will be kept on file."

As a result of the work done through this nutrition program, there is every reason to expect that by proper application of the principles being established that in many instances the nutritional value of canned foods can be materially improved without additional expense to the canner and without impairing the other qualities of the final product. Much improvement can be made by elimination of those practices shown to result in excessive destruction of nutrients and by wider application of practices already in use by some canners, which have been shown to result in improved vitamin retentions. The program contemplates another assay of the important nutrients after the industry has had an opportunity to apply this new knowledge in order to keep up to date with the progress being made.

* Miss Black presented this statement in person at the conference.

References

[1] *Research Bulletin No. 2*, Oct., 1945, No. 3, Nov., 1945, American Can Company, Maywood, Ill.

[2] Ball, C. O., and Wilbur P. C., U. S. Patent No. 2,040,726, May 12, 1936.

[3] Kohman, E. F., VITAMINS IN CANNED FOODS, *Bulletin No. 19-L, Revised*, National Canners Association.

[4] Fellers, C. R., THE EFFECT OF PROCESSING ON VITAMINS IN FRUITS AND VEGETABLES, *Bulletin No. 338*, Dec., 1936, Massachusetts Agricultural Experiment Station.

[5] Fixsen, M. A. B., THE VITAMIN CONTENT OF HUMAN FOODS AS AFFECTED BY PROCESSES OF COOKING AND CANNING, *Nutrition Abstract and Review, Vol. 8*, 281-307 (1938).

[6] Daniel, E. P., and Munsell, H. E., VITAMIN CONTENT OF FOOD, MISCELLANEOUS PUBLICATION *No. 275*, June, 1937, U. S. Department of Agriculture.

[7] Booker, L. E., Hartzler, E. R., and Hewston, E. M., A COMPILATION OF THE VITAMIN VALUES OF FOODS IN RELATION TO PROCESSING AND OTHER VARIANTS, *Circular No. 638*, May, 1942, U. S. Department of Agriculture.

[8] *Recommended Dietary Allowances, Revised 1945, Reprint and Circular Series Number 122*, Aug., 1945, National Research Council.

[9] *Nutritive Aspects of Canned Foods, (1937)*, American Can Company, New York, New York.

[10] *Canned Food Reference Manual, (1939)*, American Can Company, New York, New York.

[11] Clifcorn, L. E., THE NUTRITIVE VALUE OF CANNED FOODS, I. Introduction and Sampling Procedure, *J. Nutrition 28*, 101, 1944.

[12] Pressley, A., Ridder, C., Smith, M. C., and Caldwell, E., THE NUTRITIVE VALUE OF CANNED FOODS, II. Ascorbic Acid and Carotene or Vitamin A Content, *J. Nutrition 28*, 107, 1944.

[13] Ives, M., Wagner, J. R., Elvehjem, C. A., and Strong, F. M., THE NUTRITIVE VALUE OF CANNED FOODS, III. Thiamine and Niacin, *J. Nutrition 28*, 117, 1944

[14] Thompson, M. L., Cunningham, E., and Snell, E. E., THE NUTRITIVE VALUE OF CANNED FOODS, IV. Riboflavin and Pantothenic Acid, *J. Nutrition 28*, 123, 1944.

[15] Brush, M. K., Hinman, W. F., and Halliday, E. G., THE NUTRITIVE VALUE OF CANNED FOODS, V. Distribution of Water Soluble Vitamins Between Solid and Liquid Portions of Canned Vegetables and Fruits, *J. Nutrition 28*, 131, 1944.

[16] Hinman, W. F., Brush, M. K., and Halliday, E. G., THE NUTRITIVE VALUE OF CANNED FOODS, VI. Effect of Large-Scale Preparation for Serving on the Ascorbic Acid, Thiamine, and Riboflavin Content of Commercially Canned Vegetables, *J. Amer. Diet. Assn. 20*, 752, 1944.

[17] Hinman, W. F., Brush, M. K., and Halliday, E. G., THE NUTRITIVE VALUE OF CANNED FOODS, VII. Effect of Small Scale Preparation for Serving on the Ascorbic Acid, Thiamine, and Riboflavin Content of Commercially-Canned Vegetables, *J. Amer. Diet. Assn. 21*, 7, 1945.

[18] Kramer, A., THE NUTRITIVE VALUE OF CANNED FOODS, VIII. Distribution of Proximate and Mineral Nutrients in the Drained and Liquid Portions of Canned Vegetables, *J. Amer. Diet. Assn. 21*, 354, 1945.

[19] Wagner, J. R., Ives, M., Strong, F. M., and Elvehjem, C. A., THE NUTRITIVE VALUE OF CANNED FOODS, IX. (incorrectly numbered VII) Effect of Commercial Canning and Short-Time Storage on Ascorbic Acid Content of Grapefruit Juice, *Food Reserach 10*, 469, 1945.

[20] Ives, M., Zeppelin, M., Ames, S. R., Strong, F. M., and Elvehjem, C. A., THE NUTRITIVE VALUE OF CANNED FOODS, X. Further Studies on Riboflavin, Niacin and Pantothenic Acid, *J. Amer. Diet. Assn. 21*, 357, 1945.

[21] Guerrant, N. B., Vavich, M. G., and Fardig, O. B., THE NUTRITIVE VALUE OF CANNED FOODS, XI. Comparison of Vitamin Values Obtained by Different Methods of Assay, *Ind. & Eng. Chem., Anal. Ed. 17*, 710, 1945.

[22] Vavich, M. G., Stern, R. M., and Guerrant, N. B., THE NUTRITIVE VALUE OF CANNED FOODS, XII. Determination of Ascorbic Acid of Fresh Green Peas, *Ind. Eng. Chem., Anal. Ed. 17*, 531, 1945.

[23] Guerrant, N. B., Vavich, M. G., and Dutcher, R. A., THE NUTRITIVE VALUE OF CANNED FOODS, XIII. Influence of Times and Temperatures of Storage on Vitamin Contents, *Ind. and Eng. Chem. 37*, 1240, 1945.

[24, 25] Wagner, J. R., Strong, F. M., and Elvehjem, C. A., THE NUTRITIVE VALUE OF CANNED FOODS, XIV. Effect of Commercial Canning Operations on the Ascorbic Acid, Thiamin, Riboflavin, and Niacin Content of Vegetables, XV. Effect of Blanching on the Retention of Ascorbic Acid, Thiamin, and Niacin in Vegetables, *Ind. Eng. Chem.* (Accepted for publication).

[26] Kramer, A., THE NUTRITIVE VALUE OF CANNED FOODS, XVI. Proximate and Mineral Composition, *Food Research* (Accepted for publication).

[27] Ives, M., Pollard, A. E., Elvehjem, C. A., and Strong, F. M., THE NUTRITIVE VALUE OF CANNED FOODS, XVII. Pyridoxine, Biotin, and Folic Acid, *J. Nutrition* (Accepted for publication).

Possibilities in Electronic Sterilization

By H. A. Benjamin and O. F. Eckland, Research Department, American Can Company

CANNING PROBLEMS CONFERENCE

The increasing general interest in the use of electronic heating in food processing is reflected by the number of recent articles published on this subject. Moyer & Stotz (1) describe the blanching of vegetables using high frequency electrical energy. The heating of meat for cooking or sterilization is discussed by Wenger (2), Sherman (3) and Zarotschenzeff (5). Sherman (6) describes the heating of dry cereals for destruction of insect infestation. Most of these recent publications show an appreciation of the problems involved in the electronic sterilization of foods and do not predict a commercial application of this method in the near future. It is hoped that the work herein described will further clarify the problem of electronic food sterilization.

The basic advantage of electronic heating is that large masses of dielectric material can be rapidly and uniformly heated. If successfully applied to food sterilization, electronic heating might reduce from hours to minutes the time necessary to sterilize certain products, thus resulting in improvement in product quality.

A method of electronic processing would necessarily be more costly to operate than conventional methods of processing; consequently the product would have to command a premium price as a superior product. It is not expected that a quality improvement could be effected in the processing of rapid heating canned vegetable products such as peas and lima beans, etc., because steam processing methods are already known which will produce sterile products without overcooking. Vegetable purees and other semi-fluid products, although usually considered to be conduction heating, can be flash sterilized in tubular heat exchangers. The principal field where electronic heating might be used to advantage is in the processing of meats where the improved quality of the relatively expensive product might offset the cost of the electrical process. Meat products were, therefore, of primary interest in the study of electrical sterilization.

Equipment

For this investigation, a 15 kilowatt output, 10 megacycle frequency, radio frequency generator was used as a power source. Connected to the generator was a pair of applicator plates between which the food container was placed for heating. These plates were located in a copper lined cubical steel pressure chamber about 26" on a side, the electrical leads entering the chamber through glass bowl insulators. The high tension lead connection from the generator to the applicator was contained in a steel shield. A strip of copper about 4" wide was located along the inside top surface of the shield to reduce electrical losses and to serve as the ground. An adjustable inductance in this transmission line permitted matching the load to the generator.

Pressure as high as 45 lbs. per square inch could be maintained inside the pressure chamber in order that a food product in a sealed container could be heated to about 250° F. without undue strain on the container.

An adjustable support in the chamber permitted lowering the container away from the applicator plates into a tank of water for further heating or cooling following electrical heating. The water before entering the tank first passed through a heat exchanger so that any desired water temperature could be obtained. An automatic drain valve in the pressure chamber prevented the water from filling the chamber.

Experimental Work

The heating tests conducted can be divided into two groups according to the method of applying the radio frequency energy to the food. In the first series of tests, the energy was applied to the sides of a 500 ml. tall form pyrex beaker by means of shaped electrodes located on opposite sides of the beaker. Because of the difficulties encountered and the slow rate of heating obtained, no samples were prepared by this method.

The maximum heating rate, obtained when heating approximately one pound of pumpkin with the electrodes located on the sides of the beaker, was about 4° F. per minute with a temperature spread across the beaker of 21° F. after a heating period of 18.5 minutes. The temperature distribution could probably have been improved by adopting a "push-pull" coupling of the load to the generator. The heating rate was limited because an increase in radio frequency voltage caused arcing through the walls of the beaker. An air gap of about ¼" between the electrodes and the beaker was found to permit the most rapid rate of heating without arcing. Tendency toward arcing was greatest at the top surface of the product. The rate of heating of the product decreased as the salt content of the product was increased. Tendency toward charring of particles adhering to the side of the beaker above the top of the product was noted.

In the second series of tests sterile samples of pea puree (inoculated), luncheon meat and Vienna sausage were prepared by electrical heating in a container consisting of a 90 mm. diameter Pyrex tube fitted with two metal ends. The metal ends of the container acted as electrodes and were in actual contact with the food to be heated. A container of this type is described by Bohart (7). Heating times varied from 0.5 to 5.0 minutes. After electrical heating, the container was lowered into a tank of hot water and held at a temperature of 250-255° F. for a long enough period, usually about five minutes, to complete the sterilization of the product and to sterilize the walls of the container. This was necessary because the glass container received heat only by conduction from the product and consequently the inner walls of the container were much cooler than the product at the center of the container. The container was then cooled.

Although radio frequency energy was used to heat this container in most tests, a few tests were conducted in which ordinary 110 volt, 60 cycle current was applied. Since the product was heated almost as rapidly by 60 cycle current, the product must not have been dielectric in nature and heating must have been largely by resistance. Rather severe corrosion of the metal ends resulted from the 60 cycle heating. (Low frequency current would, of course, not be effective in heating through the sides of a glass container.)

Results

Some improvement in flavor and texture was noted in the luncheon meat and Vienna sausage, electrically processed, However, the numerous limitations of electronic heating in the double ended container tend to make this method impractical.

Among the difficulties encountered were local heating, arcing and burning which resulted from poor contact between the metal ends and the product being heated. The slower the heating, the less trouble encountered in this respect. It should be noted also that any local overheating resulted in the development of high pressure in the container which usually forced an end from the container.

Since the product had to be in contact with the two metal ends, the container was processed on its side and the headspace had to be on the side of the container. This resulted in a poor appearance and excessive free liquid in a solid product like luncheon meat.

When brine was used, it was found that it had to have about the same electrical conductivity as the solid product or uneven heating resulted.

The immersion of the container in hot water for the holding or sterilizing period was deemed necessary because lower temperatures were obtained in the product near the container walls than in the center of the product during this period. These lower temperatures resulted from heat lost to the container, the glass walls of which absorbed very little electronic energy, and to radiation and conduction losses during the holding period. Furthermore, since the outer portions of the product were cooled first during the cooling period, they actually received a shorter holding time than the center of the product. By immersing the container in water at a temperature a few degrees higher than that in the center of the product it was possible to equalize the sterilizing treatment given the inner and outer portions of the product.

Fairly uniform heating of the homogenous products was obtained in both series of tests although when radio frequency power was applied to the side of a beaker the heating was so slow that the temperature could have evened up to a considerable extent by conduction and radiation from the surface. Heating of non-homogenous products such as meat containing layers of fat was far from uniform. In one test where fresh ham was being heated, a temperature of about 260° F. was indicated by one thermometer, while another a little over an inch away indicated a temperature of only 190° F. On examination of the meat, some of the fat was found to be scorched, while part of the lean was still raw.

Tests were made to determine whether the available high frequency field had any effect on the viability of spore forming bacteria when heat was not permitted to become a factor. In these tests, suspensions of thermophilic flat sour spores in neutral phosphate solution were exposed to a radio frequency field in 500 ml. cotton-stoppered Pyrex bottles. The suspensions contained various amounts of salt. With a sample containing 3.5 percent salt located between the shaped electrodes, the generator output was adjusted just below the point where arcing would result. Without further changing the output of the generator, three sets of duplicate samples were exposed to a high frequency field for 10 minutes. The temperature rise obtained in the .75 percent salt samples was 16° F. with a slightly higher rise being obtained in the salt free samples and less heating being obtained in the 3.5 percent salt samples. The output voltage of the generator was 9600 volts.

Per cent Salt Content	Av. Spore count/ml. before exposure	Av. Spore count/ml. after exposure
0	510	635
0.75	625	766
3.5	660	890

It is evident from the above table that there was no reduction in spore count as a result of the radio frequency treatment. It appears that the exposure may even have activated the spores which resulted in an increase in the percentage germination of the spores; however, there is some question whether the differences shown are of any significance.

Fleming (8) reports more extensive work on the effect of radio frequency fields on the viability of microorganisms and his results showed a definite lethal effect in weak electrolytes. This would appear to be a fertile field for further research.

It is concluded from these experiments that, although a method of radio frequency processing may be developed, the application will be a difficult one. Woll (4) reached a similar conclusion. The arcing which caused so much difficulty in electronic heating at 10 megacycles possibly could be reduced by the use of higher frequency fields. This was demonstrated by Moyer and Stotz (1) who used a frequency of 150 megacycles in blanching vegetables. It is probable that frequencies in this or a higher range will result in more uniform heating of nonhomogenous products. At the present time, however, high power ultra high frequency equipment is not available.

The authors are indebted to Mr. Wiley D. Wenger, Mr. John Dawson and Mr. A. H. Prow of the Radio Corporation of America for invaluable assistance in the technical phases of this investigation. The radio frequency generating equipment was loaned by the Radio Corporation of America.

References

(1) ELECTRONIC BLANCHING OF VEGETABLES. J. C. Moyer and E. Stotz, *Science, 102*, 68-9, July 20, 1945.

(2) USE OF DIELECTRIC HEATING FOR STERILIZATION, PASTEURIZATION, COOKING AND ENZYME CONTROL IN FOODS AND DRUGS, W. Wenger, *Electronics, 18*, 154, March 1945.

(3) ELECTRONIC COOKING AND STERILIZATION OF FOODS, V. W. Sherman, *Electronics, 17*, 150, July 1944.

(4) ENGINEER SAYS DIELECTRIC HEAT WON'T BE IN COMMON USE FOR A LONG TIME, *Food Field Reporter, 12*, #25, 40, Dec. 11, 1944.

(5) WILL DIELECTRIC HEATING PAVE THE WAY FOR SOUTH AMERICAN MEAT? M. T. Zarotschenzeff, *Meat, 22*, #11, 21-23, December 1944.

(6) ELECTRONIC STERILIZATION IN THE PACKAGE, V. W. Sherman, *Modern Packaging, 17*, 99, February 1944.

(7) U. S. PATENT 1,911,879, George S. Bohart, May 30, 1933.

(8) EFFECT OF HIGH FREQUENCY FIELDS ON MICRO-ORGANISMS, Hugh Fleming, *Electrical Engineering*, Jan. 1944, p. 18.

Current Suggestions on the Processing of Tomato Juice

By E. J. Cameron, Director,
Washington Research Laboratory

CANNING PROBLEMS CONFERENCE

Introduction

This report is not the product of one person, but rather of a group to which we may refer as a committee made up of representatives of various laboratories connected with the canning industry. The first report, which was not made public, was drawn last year and there have been two revisions of it. This is the last and has just come to me from Mr. Benjamin, of the Research Division of the American Can Company, who accepted the responsibility of modifying the first revision.

In the canning of acid products, unfortunately, we do not have as a guide a criterion of process efficiency, or a measuring stick, such as we have in arriving at processing for low-acid foods. There we have a basic resistance value (that for *Clostridium botulinum*), which applies to all such foods, and processes must be sufficient to destroy this organism. It is true that there may be process differentials of greater or less degree to limit the possibilities of spoilage by the more resistant thermophilic spoilage organisms, but the basic requirement is that which I have indicated.

On the other hand, in canning tomato juice we recognize that in the usual commercial handling we cannot cope with two spoilage organisms, i.e., *Bacillus thermoacidurans* and *Clostridium pasteurianum*, if their spores are present in significant numbers. In other words, we are thinking in terms of pasteurization rather than sterilization, and we recognize that control of spoilage by the two spore-forming spoilage types depends on prevention of contamination by them. The very low incidence of spoilage in tomato juice over the past several years testifies to the success of the control measures that have been applied in the industry, rather than dependence upon process.

With this as background, I will read the committee's report. I wish to call to attention, however, that this does not cover all technological practices in use in this country today. For example, we are not suggesting processes where rotating cookers are used, nor are we making recommendations for still processes at temperatures higher than 212°F. Where these or other practices not covered by the report are in question, the canner should seek advice of a laboratory connected with the canning industry.

Processing of Tomato Juice

All procedures included in this statement carry the qualifications that strict attention be paid to clean up procedures in order to hold to a minimum contamination by spoilage organisms. This involves such things as elimination of wooden equipment, thorough washing several times daily of tanks, conveyor belts, juice machines, etc., dismantling of pumps and fillers to insure adequate cleaning, and rigid inspection to see that the clean up is efficiently carried out. Of the five procedures described, only the first can be relied on to protect against contamination by heat resistant organisms of the *B. thermoacidurans* type. These organisms may cause flat sour or swell type spoilage.

1. Method of Handling Cans Filled with Presterilized Juice

Tomato juice may be presterilized by heating in continuous heat exchangers to temperatures substantially above the boiling point. A common practice is to provide a sterilization of time and temperature equivalent to about 7/10 of a minute at 250°. This procedure minimizes the chances of survival of the flat souring organism, *B. thermoacidurans*. In order to provide an equivalent degree of protection against this organism in a conventional steam cook, it would be necessary to process No. 1 cans of tomato juice for 140 minutes at 212°F. Because the juice must be cooled below the boiling point for filling into non-sterile cans it is necessary to make provision for the sterilization of the containers. For No. 10 cans, a closing temperature of 190 to 195°F. (which may be provided by a filling temperature of not less than 195°F.) should provide for the container sterilization if the cans are held before cooling for not less than three minutes. For smaller cans, slightly higher closing temperatures are suggested; for instance, 195° to 200°F. From theoretical considerations, an equivalent container sterilization is provided by a 200 to 205°F. closing temperature followed by a

one-minute hold before cooling. In order to provide for sterilization of the can cover, it is well to invert the cans as they leave the closing machine. Inoculating experiments have shown this to be a necessary procedure, if sterilization of the cover is to be assured. If necessary to wash the cans after closing, water at not less than 200°F. should be used. There are practical difficulties that sometimes make it impossible to maintain a minimum closing temperature of 200°F. (requiring a filler bowl temperature of not less than 205°F.) in every can, and therefore, the safer procedure is to use the longer holding time of three minutes. In addition, more difficulty will be experienced with slack filled and paneled cans with the higher closing temperature. While recognizing the feasibility of reducing the holding time with an increase in closing temperature without impairing the efficiency of the sterilization, it is evident that the adoption of the shorter-time-higher-closing temperature procedure removes some of the canner's operating safety factor.

2. Method of Handling Juice Without Either a Retort or a Presterilization Procedure

In some plants not equipped to presterilize tomato juice, the product is hot filled, given a holding period in air, and then water cooled. It is possible to preheat this juice to obtain a closing temperature of 200-205°F. (provided by a minimum filler bowl temperature of 205°F.), and hold the inverted hot cans before cooling, for a time sufficient to complete the sterilization of the juice and the inside surface of the can and cover. As for Method 1, inversion of the cans at closing is desirable. Any reduction in temperature due to washing with cold water after closing will reduce the sterilizing value. Therefore, it is important, if cans require washing after closing, that water at not less than 200°F. be used. The holding time required before cooling depends on a number of factors which are difficult to evaluate. Under some near ideal conditions, it may be possible to use this process successfully with a holding time as low as three minutes although this heat treatment does not carry the protection provided by conventional boiling water processes nor does it provide any significant protection against organisms such as *B. thermoacidurans*.

3. Method of Handling Cans Which Are to be Air-Cooled Following Hot Filling

This method involves relatively high labor costs and space requirements. In canneries equipped for air cooling other products, it is often advantageous to handle tomato juice by this procedure. In such cases, it is suggested that No. 2½ and smaller can sizes be closed at not less than 195°F. (which may be provided by a filler bowl temperature of not less than 200°F.) and that larger can sizes be closed at 190°F. (which may be provided by a filler bowl temperature of not less than 195°F.). If necessary to wash the cans after closing, water at not less than 200°F. should be used. Care should be taken to see that the cans are inverted after closing and ricked or stacked to allow air circulation between cans, otherwise they will not cool properly and difficulties associated with hot storage will be encountered. These difficulties are loss in quality of the product and reduced container service life.

4. Method of Handling Cans Processed in Boiling Water in Conventional Manner Without Agitation

Suggested boiling water processes for tomato juice are listed below:

Can Size	Initial Temperature	Time
300 x 407	170° F	35 minutes
300 x 407	180° F	30 minutes
300 x 407	190° F	20 minutes
300 x 407	195° F	15 minutes
300 x 407	200° F	10 minutes
307 x 409	170° F	40 minutes
307 x 409	180° F	35 minutes
307 x 409	190° F	25 minutes
307 x 409	195° F	15 minutes
307 x 409	200° F	10 minutes
46-ounce	170° F	60 minutes
46-ounce	180° F	45 minutes
46-ounce	190° F	30 minutes
46-ounce	195° F	15 minutes
46-ounce	200° F	10 minutes
603 x 700	170° F	90 minutes
603 x 700	180° F	70 minutes
603 x 700	190° F	35 minutes
603 x 700	195° F	15 minutes
603 x 700	200° F	10 minutes

The initial temperature is the temperature of the juice at the time the process is started. A systematic check should be made to ascertain if the intended initial temperature is maintained.

5. Method of Processing Juice in Continuous Agitating Type of Cooker

Tomato juice is sometimes processed in cookers designed for revolving the cans or spinning them rapidly about their axis while in a water bath or spray at temperatures near boiling. Substantially lower times are required in this type of cooker than for the steam retort type of cooker described under Method 4. The specific times required are dependent on a number of factors such as headspace, rate of rotation, etc. Processing times for this type of cooker can best be established by measurement of the can temperatures under the specific processing conditions involved. In some sections of the country, it is necessary to attain final temperatures of 205°F. for juice which is to be water cooled, to provide protection against spoilage organisms of the *Cl. pasteurianum* type. For juice which is to be air cooled, a final temperature of 195°F. has been found to be satisfactory. Somewhat lower final temperatures than these may be satisfactory if the *Cl. pasteurianum* organism is not a contaminant, but in any case this processing method is not considered adequate to prevent spoilage caused by organisms of the *B. thermoacidurans* type.

Illumination Studies in Canning Plants

By H. K. Wilder, N.C.A. Western Branch Laboratory

PLANT SANITATION AND WASTE DISPOSAL CONFERENCE

About 15 years ago I was confronted with the problem of organizing an effective system of quality control which would ensure the maintenance of high and uniform quality in a line of food products which were manufactured in large volume and throughout the twenty-four-hour period of each day. Manufacturing operations had been developed to a high degree of efficiency and we had loyal, conscientious workers, but in spite of these favorable conditions the quality of the manufactured products sometimes fell below the high standards which the company sought to maintain.

One of the first steps in seeking to remedy this condition was to take hourly samples from every production line for laboratory examination. Within a few weeks it became apparent that the deviations in quality had a definite tendency to recur at about the same time on different days; color of the product went light or dark in late afternoon, early morning, or sometimes about noon; dark specks of overheated product appeared most generally on a night shift; and in one instance imperfect units kept turning up with surprising regularity for no apparent reason.

To correct these faults we detailed trained inspectors to check closely the operations, and in some of the especially puzzling problems I myself attempted to demonstrate to the workers how their performance could be improved. You may imagine our surprise when we discovered that in a number of instances even the hand-picked inspectors were unable to perform the tasks satisfactorily.

What we found was that in numerous instances the fault was due to improper lighting, generally too little, sometimes too much, particularly in the glare of noon-day sunshine streaming in through the windows. Sometimes an old, but reliable worker, had been placed at the task, and we found that she required much stronger light than did younger workers on other shifts to perform the same task in an acceptable manner.

Thus there began intensive studies whereby we sought to fit the lighting to the requirements of the task, and the results which we achieved, even

without the advantages of present-day lighting fixtures, were very satisfying.

With this background of experience you may perhaps understand my interest when I was asked to serve as the industry's representative on a subcommittee of the Illuminating Engineering Society whose purpose it is to make a study of lighting requirements in the canning industry.

Importance of Lighting

The importance of better lighting is appreciated by the managements of many canneries, and it has been emphasized by the experienced sanitarians who have been engaged by the N. C. A. to conduct plant sanitation surveys. Survey reports repeatedly stress the importance of good lighting in its relation to plant sanitation, from the standpoints both of product contamination and the so-called "environmental sanitation." The prevention of product contamination may necessitate better lighting to permit proper cleaning of plant, equipment, materials, and containers. "Environmental sanitation" involves lighting which will ensure greater cleanliness in the plant to prevent health hazards, better light to avoid accidental injury to employees, and relief from the eye strain which is involved in performing the difficult seeing tasks incident to many important cannery manual operations.

It is indeed fortunate that, at a time when the need is being stressed for better lighting in canneries, we have a committee of lighting engineers already undertaking studies of the seeing tasks involved in canning, and of practical means for improving existing conditions. I mention studies of "seeing tasks" because I have learned in my frequent contacts with this group of engineers that their approach to the problem is a much broader one than that of simply recommending higher intensities or more lighting fixtures. The lighting engineer sees in a cannery, first, the problem of properly lighting the general areas of plant operation, fitting the illumination in each department to the requirements of the tasks being performed there. Secondly, he sees the many tasks which require special lighting to supplement that afforded by the illumination of the general areas. Lighting, in its broader sense, may encompass the proper use of daylight and it supplement during daylight hours as well as lighting derived entirely from artificial sources.

Four-point Seeing Task

Each seeing task is analyzed from at least four standpoints:

1. The size of the objects to be seen,
2. The degree of contrast between the objects and their surroundings,
3. The time during which the objects may be observed, and
4. The brightness of the objects.

Going further, the engineer gives consideration to glare and its effect on the eyes and on seeing, to diffusion, to shadows, to the direction, and to the color quality of the light, because all of these enter into the seeing problem.

My own status on this committee is not as a specialist in illumination, but as one to provide liaison between the I.E.S. committee and the canning industry. My functions are to inform the committee as to the lighting problems which require study, to facilitate contacts of the committee with canneries, to seek means for assisting and expediting the studies, and, finally, to see that the canning industry is informed concerning the activities and results achieved by the subcommittee and its associates in the Illuminating Engineering Society. Since this constitutes my first report to the industry as a whole, I would like first to tell you something of this committee and of its parent organization.

The Illuminating Society

The Illuminating Engineering Society was organized in 1906 "for the advancement of the theory and practice of illuminating engineering and the disseminating of knowledge relating thereto." The Society now has 3,300 members who are interested in the subject of lighting from various standpoints: engineering, economic, hygienic, and aesthetic. The Society is not affiliated with any commercial organization and anyone interested in its objects may become a member. As an aid to architects, engineers, and others who are called upon to design or recommend installations of lighting equipment, the Society publishes a code of lighting for factories, mills and other work places under the title "American Recommended Practice of Industrial Lighting." This publication discusses the advantages of good illumination from such standpoints as accuracy of workmanship, increased production, better utilization of floor space, improvement of seeing ability of older employees, decreased eye strain among all employees, improved morale of employees, plant cleanliness, and reduction of accidents. As an indication of the close relationship between lighting and plant sanitation and hygiene, it is of interest that a reprinting of this I.E.S. Code was issued under the title "Industrial Hygiene and Plant Efficiency Through Good Lighting."

The Code presents the information which is available relative to minimum standards of illumination for various industries and for specific work tasks which have been studied. Detailed recommendations are included in the code for a number of industries in which specific studies have been made, and thus far nearly a dozen supplementary bulletins have been published, each giving detailed lighting recommendations for a specific industry.

Since the code contained no detailed recommendations for the canning industry, and since this industry is one of major importance in California, a committee of lighting specialists resident in the San Francisco Bay area was appointed in 1944 to conduct studies with a view to developing lighting recommendations for canneries. Committee members were selected so as to have representation from a lighting equipment manufacturer, a lamp manufacturer, a power company, an electrical contractor, a consulting engineer, and a representative of the National Canners Association.

It was first necessary for the members of the committee to familiarize themselves with canning operations, in order to learn the nature of the seeing tasks involved in the preparation and canning of foods. The committee has visited numerous canning plants during night operations and has observed the canning operations on such products as canned asparagus, fruit cocktail, peaches, pears, peas, tomatoes, tomato products, and a few strained foods.

This committee has continued its work, endeavoring to establish standards for lighting in canneries, and at present it is engaged in the preparation of tentative recommendations covering the lighting requirements of the general areas.

Variability a Problem

The preparation of specific recommendations has been found difficult because of the wide variability in cannery construction, operating practices, and the types of products being canned. Classification of canning equipment and operations presents a problem, not only because of the variety of equipment and procedures used in canning different products, but also because of the several methods employed to accomplish a single purpose in different canneries. For example, a method of lighting canning sinks or belts which would be suitable where cans are distributed by hand truck would be entirely unsuitable in a plant using a can distributing system in which a complex series of overhead can conveyors interferes with distribution of light in the usual fashion. The seeing tasks involved in the proper inspection and sorting of various types and colors of fruits and vegetables, each having different kinds of associated material or defects, present difficult and individual problems. The necessary practice of washing the raw material before sorting and trimming introduces a problem in the elimination of specular reflection of light from the wet surfaces so that maximum visibility of defects and minimum eye strain may be achieved.

Thus, the work of the committee has served to indicate the variety and complexity of the problems involved, and is leading toward the development of tentative recommendations. Additional data on specific seeing tasks are required, and these can be ob-

tained only through a variety of tests, under both experimental and practical operating conditions.

In view of the immediate importance in the plant sanitation program of improved lighting in canneries, means have been considered for expediting the work. The committee members are key men, prominent in their respective fields, and competent to guide and supervise lighting investigations. By the same token, they are all very busy men, and are not able to devote to this extra work the large amount of time required to secure necessary data.

N.C.A. Fellowship

To seek a remedy for this situation, the committee has explored the possibility of securing aid in prosecuting the necessary research through the establishment of a fellowship at an engineering school, so as to permit research on lighting problems in the canning industry to be conducted by a research fellow under the guidance of this committee of illuminating engineers. There is at Stanford University an illuminating engineering laboratory which is well equipped, widely recognized, and known to be interested in the practical applications of illuminating engineering. It is a pleasure to inform you that, during this convention, the Board of Directors of the National Canners Association approved the appropriation of funds for establishing there a fellowship for studies on lighting in the canning industry.

The University has indicated its willingness to undertake this research as a cooperative project financed by the N.C.A. and administered under the guidance of the committee appointed by the Illuminating Engineering Society. Research will be undertaken as soon as a competent fellow can be selected.

A considerable period of time must necessarily elapse before the results of this research can become available to the industry. There has already developed, particularly among the industrial sanitarians, an insistent demand for information to guide them in improving present lighting practices in canneries. To meet that need, it is our purpose to make a search for literature now available which may provide information on industrial lighting practices.

Several useful pamphlets are known to be obtainable, and will be provided to member canners upon request.

Two reprints of recent publications are available for distribution here today. One of these entitled "Lighting for Easy Seeing," contains much information on the general principles of lighting, and should provide the layman with a brief, clear, introduction to the subject. The other pamphlet, entitled "Levels of Illumination," gives specific suggestions concerning lighting intensities which will prove useful to anyone making a serious study of plant lighting.

I have already mentioned a more comprehensive bulletin, the "Code of Lighting for Factories, Mills, and Other Work Places," which is published by the Illuminating Engineering Society. The present supply of this bulletin is too limited to permit its general distribution here, but copies will be procured for member canners who request them. The bulletin provides not only a splendid discussion of the principles of industrial lighting, but also a table of "Recommended Minimum Standards of Illumination for Industrial Interiors." This table is similar to that in one of the pamphlets which I have for distribution today, except that the data tabulated in the newer pamphlet are intended to reflect *good* practice rather than the *minimum* values presented in the I.E.S. bulletin.

I should tell you now that, whereas the data are quite complete for a number of industries, there is but one light intensity value given for "Canning and Preserving," namely 20 foot-candles. It is to supply data in this obviously deficient field that the I.E.S. committee, about which I have been telling you, was formed.

References

[1] AMERICAN RECOMMENDED PRACTICE OF INDUSTRIAL LIGHTING, *Illuminating Engineering Society*, New York (1942).

[2] LIGHTING FOR EASY SEEING, Matthew Luckiesh, *Architectural Record*, 93: 54 (1943).

[3] LEVELS OF ILLUMINATION, Walter Sturrock, *Magazine of Light*, 130-140 (1945).

Practical Rodent Control for Canning Plants

By M. D. Pirnie, Director, Kellogg Bird Sanctuary, Michigan State College

PLANT SANITATION AND WASTE DISPOSAL CONFERENCE

To be effective, a program of rodent control must be biologically sound and economically practicable. It must be dignified, and respected as a part of the factory's sanitation effort. Trained help is essential; and one person should be made responsible for carrying out this program.

Effective control (eradication) is largely a matter of common sense plus a little effort. Rats are not as smart as humans are lazy. Rats are always ready to make themselves at home and to raise large families if food and shelter are available. In food processing plants rodent control is urgent, because risk of pollution must be eliminated. A single rat or mouse is one too many in a food factory; yet many plants are now operating with too little attention to this phase of sanitation.

Rodent infestations in a plant require more than a scattering of poison baits. The eradication program should start with complete ratproofing as well as killing off the existing populations of rats and mice. Then this should be followed by a continuous trapping program to prevent reinfestations and to maintain sanitary conditions. Control methods are briefly outlined below:

Ratproofing

Ratproofing means the elimination of rat shelters by good construction and by adequate repairs to walls, screens, doors, storage rooms, and incinerators. It calls for closing openings where plumbing or heating pipes pass through walls. It includes doing everything possible to close access to rodents. (Screening against sparrows and doves also should not be overlooked.) True, doors must be open much of the time, but, so far as possible, the doors to food storage rooms should be closed; and the walls should be rodent-proof. Use heavy, ¼-inch mesh hardware cloth over ventilation openings and spaces difficult to inspect.

Refuse Disposal

Rodents often find shelter and food in heaps of trash and foods scattered close to the cannery. In cold weather these animals seek warmth and food in the buildings. It is better to store such trash or refuse in special rooms or buildings, preferably apart from the main factory. Such temporary storage spaces should be fireproof and ratproof. Concrete floors and walls discourage rats and mice. Avoid dirt or wood floors at incinerators or rubbish storage.

Waste solids carted to dumping grounds should be dumped according to the rules for sanitary dumping. Instead of scattering widely or over an extensive front, all dumping should be concentrated at a limited space, then graded and top-dressed. Rats do not like "managed" dumps.

Killing Methods

Fumigation or gassing is recommended for treating ground dens. Either car exhaust (carbon monoxide) or calcium cyanide (Cyanogas) may be used. The complete fumigation of buildings, as in feed mills and warehouses, kills all mice and rats. Such fumigations are done only once or twice a year, as a rule, and rodents can increase and become very destructive in the meantime, unless ratproofing is done and other killing methods are employed.

POISONS

Poisons are used extensively by most pest control operators. Poisoning "looks easy", but actually it is just as difficult to poison successfully as it is to "trap out" a population of rats or

mice. Not all the animals will take the baits; and animals made sick by a certain poison may refuse to take more of it later. The odor from dead rodents back of partitions or under floors is one objection to poisoning; but a greater objection in a food factory is the danger of poison getting into the product. Where poison is to be used, probably red squill is one of the best and safest. "ANTU", one of the new poisons, may become just as useful; but another of these, "1080", will have restricted use, due to its deadliness.

TRAPPING

Trapping, in my experience, has proved very successful in year-round protection from rodents. Newly arriving animals are not difficult to trap; it is those that have become established that bother. Considering the objections to poisons and fumigations, trapping seems to me the best protection in food processing plants.

Probably snap traps are best for catching the Norway rat and house mouse. If to be baited, the small triggers are adequate; but a larger, cardboard trigger is an advantage in runway trapping, outlined below. (No. 1 or No. 0 steel traps also are used with success.) The electric trap now available on a rental basis, like all traps, must be placed where the animals are likely to travel. Trapping failures usually are due to one of the following faults: too few traps, traps not set in runways, or traps not guarded from accidental discharge. All traps should be tended daily in warm weather to prevent odors.

Mice are easily caught in snap traps baited with a little peanut butter pressed into the trigger. Canned meats, bacon grease, grains, salt, and sugar also are excellent baits. Place the traps wherever signs of mice are noticed. Screw several traps to a board to prevent loss of traps. A series of traps is better than singles. For trapping along walls, place the traps with triggers toward the wall. A box cover will be an advantage at times to prevent springing of traps by workers.

Rats are most successfully taken in *runway* trapping. This means placing the traps against walls, as in mouse trapping. Being creatures of habit, they cannot always be drawn to baited traps set away from natural runways.

In setting up a permanent trapping program we recommend "trapping boxes" or covers for runway trapping along walls. These boxes (of 1 inch boards) are about 16" long, 10" wide, and 7" high, with or without a back or floor. An imitation rat hole is cut at each end, close to the wall and at floor level. Two snap traps are set inside, with triggers pointed toward these openings. Tipping the half-box away from the wall or raising a hinged lid permits tending the traps. Bait is not necessary; but rats are attracted to whole corn. The advantage of the boxes is two-fold—to create rat shelter and to protect the traps from accidental discharge. They help "dignify" the trapping effort. If fastened to the box by small chains, traps are less likely to be lost or taken.

Trapping boxes should guard all rooms opening to the outside and also inside any room where food or shelter may attract rodents.

The objective is freedom from contamination. No trapping will give this unless the job receives faithful attention by an intelligent worker. This is no job to be turned over to the least effective workman. The better the construction and maintenance, the fewer traps will be required; but those are valid insurance against rodent troubles.

MEASURE SUCCESS BY THE ABSENCE OF RODENTS, NOT BY THE NUMBERS KILLED!

Inspections

Inspections are a vital part of rodent control. Armaments alone never won battles; it was the appropriate use of them that turned the trick. So it is with trapping rodents. New hazards are bound to develop; and there always is a possibility of rats or mice getting into canneries. All workers should be encouraged to report any rodent signs at once. Competent *weekly* inspection is recommended. The trained inspector will note ratproofing needed, any laxity in maintenance, and any rodent tracks or damage. He will make sure the trapping program is kept operating. Each subsequent check-up will reveal if repairs and improvements have been made promptly. His work is part of the plant protection and sanitation program and it should be recognized as essential to production. Experience has shown the vital need of this perpetual action program, if sanitation is to be attained.

Summary

Rodent control is imperative. It need not be expensive. Like any safety or fire prevention effort, rodent eradication requires persistence and a fair degree of intelligence. Responsibility should be placed on one person, aided by *all* the staff.

Sound construction and careful maintenance are the basis of rodent control; but certain protective measures must be continued after eradication has been accomplished. Trapping in box runways (both outside and inside "hazard" openings) should be practiced at all times.

Rodents thrive chiefly where people are lazy or indifferent to the food losses and disease risks they are responsible for. The success of any control is no better than the capabilities of the man in charge. *Pick a good man for this phase of plant sanitation.*

Cleaning Problems in the Canning Plant

By C. W. Bohrer, N.C.A. Washington Research Laboratory

PLANT SANITATION AND WASTE DISPOSAL CONFERENCE

Among the items with which canners are concerned in their sanitation program probably none occupies a more prominent place than adequate cleaning of their food preparation machinery and equipment. Canners desirous of improving the efficiency of their present clean-up procedures may encounter certain difficulties. For purposes of this discussion a number of problems considered of importance in any cleaning program are presented and some suggestions offered.

Problem 1.—Time for Cleaning

A thorough and complete clean-up of all equipment used should be made at the end of each day's operations and quick clean-ups made when necessary during rest periods throughout the day. In some cases operating schedules are often so heavy that only a limited amount of time can be allocated to clean-up. This practice may not be a judicious one since it may result in spoilage, faulty sanitation or both. The maintenance of equipment in a clean condition should be considered when production schedules are drawn up, and the production desired weighed against the danger of financial loss due to spoilage or other difficulties which such production may entail. Adequate cleaning can be accomplished with a minimum of interference with production after a study of the individual cleaning problems is made. The study should be designed to establish the most efficient cleaning procedure necessary to achieve a high degree of sanitation to eliminate lost time and unnecessary motion in attaining it.

Problem 2.—Equipment Design

Some equipment fabricated either in the home shop or commercially manufactured has been designed without due regard to sanitary maintenance. Those of us who have attempted to clean canning equipment know that certain items of equipment are extremely difficult, if not impossible, to clean adequately. In this category we find the conventional pea blancher, wooden tanks, certain types of fillers, conveyor belts, and wilters among others. It has been observed also that these same items of equipment are found frequently to be the sources of the contaminating organisms in spoilage outbreaks. In the past the manufacturer of canning equipment apparently has primarily directed his attention to the development of machinery

with increased speed of operation and production capacity. He is now concerned with supplementing these features with ease of cleaning and the elimination of spoilage hazards. A lecturer at a recent canning plant sanitation course indicated that the war has developed new techniques of metal fabrication which may find application in canning equipment manufacture. He envisioned large pieces of equipment stamped out in a single unit without dead ends or square corners and other equipment which by the simple removal of a sliding wall presented all its working parts for ready cleaning. This made a very pretty picture of the possible things to come but we are concerned with the present, however, and we must do what we can with what we have. The canner should survey his equipment with a view to cleaning needs and spoilage hazards and direct his immediate attention to working out the best cleaning methods possible with special emphasis on those items of equipment most likely to present difficulty. When replacement of present equipment is contemplated, the ease with which the new item of equipment can be cleaned should be considered along with the other desirable features, such as speed of operation and efficiency.

Problem 3.—Tools for Cleaning

In working with clean-up crews it has been observed that basic cleaning equipment is sometimes inadequate or lacking. Any job can be accomplished more quickly and effectively when the proper tools are available. After a study of the cleaning job to be done, the type of general cleaning equipment needed for rapid completion of the job should be determined and supplied where needed and in the quantity required. The reference here is to mechanical aids, such as scrapers, brushes and nozzles and to water and steam outlets. In some cases, specialized cleaning aids may be indicated or helpful.

The efficiency of any detergent is increased by the use of the material hot and under pressure. A steam gun with a fin type nozzle has been suggested for use in cleaning, by which the detergent is atomized with steam at 65 pounds pressure. The use of high pressure pumps which mix air and water has been suggested also. It has been stated that air with water at 200 pounds pressure is more effective in cleaning than water alone at 400 pounds pressure. In closed systems which can not be dismantled the detergent should be circulated back and forth a number of times to set up turbulence and increase the time of action. This can be accomplished by using a small portable pump to return the solution from one end of the system to the other through an auxiliary hose or pipe.

Problem 4.—Cleaning Crew Personnel

The type of worker assigned to clean-up is usually not of the same caliber as the worker used in production. Since the job of cleaning is an important one, more attention should be paid to the qualifications of the worker assigned to the clean-up crew. It should be possible now with the alleviation of the labor shortage and with existing minimum wage requirements to attract more competent labor for cleaning purposes. Any workman, however, may become ineffective if he is not acquainted with the problem of what he is to do, how he is to do it and why he is to do it. A reliable and competent individual should be selected for supervising and teaching the clean-up techniques which have been found suitable. Intelligent instruction can do much to overcome any lack of experience and skill and proper organization of the clean-up methods can prevent waste motion and lost time. In a recent clean-up study in a corn canning plant it was observed that one member of the clean-up crew began to clean the silker and another member of the crew to clean the cutters. When the jobs were completed, the silker had to be recleaned because all the wash water carrying the debris from the cutters had drained through the silker. It is realized that this is not a common occurrence but it serves to illustrate what can happen without proper organization and supervision. The person in charge of clean-up should be thoroughly familiar with the construction of every piece of equipment he cleans. He should know every hidden part, every dead end, every seam and corner so that he may efficiently direct the clean-up, concentrating the cleaning effort only where concentration is necessary. He should know also of any alterations that may be made from time to time to properly adjust his cleaning techniques. The following case from experience may illustrate the necessity of such knowledge: A recording thermometer was removed from the side of a corn blending tank and the opening plugged. The removal was not noted by the clean-up crew and the old thermometer well served as a "pocket" wherein thermophilic spoilage organisms found a favorable haven for multiplication, and contamination of the product occurred.

Problem 5.—Detergents

There is a widesread misconception as to the proper role of detergents. There is no all-purpose detergent, and detergents are not vested with any magical powers. In a word, the purpose of any detergent is to prepare the dirt or soil for its subsequent detachment by mechanical action and its final elimination by rinsing. A great deal of cleaning can be accomplished by intelligent use of plain hot water and elbow grease. Much remains to be done by way of scientific experimentation and research in the detergent field as applied to cleaning in the canning plant. Other food industries, such as the milk industry, have studied the use of detergents and have worked out methods for their application. Although some of the methods worked out in the related industries may have application in the canning industry to a limited extent, the multiplicity of cleaning problems in the canning plant demands separate and special study. If the canner has a special cleaning problem in which the use of a detergent is indicated, he can experiment with mixtures of the known detergent materials to get the desired results. Once established, the mixture can be purchased on specification from raw chemical manufacturers.

The chemicals which have been used alone or in combination to give desired detergent properties are in general alkalies and alkaline salts, such as caustic soda, sodium metasilicate, the phosphates—Trisodium phosphate known to the trade as "T.S.P.", tetra sodium pyrophosphate known as "pyro" and the carbonates. The strong acids have little use in the food industry but organic acids, especially gluconic acid, may have definite value as cleaners in the canning industry.

Some of the larger and more progressive detergent manufacturers have undertaken studies recently to determine the suitability of their products in cleaning canning plant equipment. In some cases the canner may desire to obtain from commercial detergent manufacturers the most suitable proprietary mixture together with the services rendered by such organizations. Should the latter course be followed the canner should have on-the-spot demonstrations of the suitability of the product offered and the proper method of application.

Now that the war is over, numerous new detergents will become available. In regard to new types of detergents, canners should keep in mind the hazard of change. Many of the new types of detergents may require methods of application which are completely different from the conventional methods. Unless the proper conditions of application are thoroughly understood, waste of expensive material may result through improper handling. The possibility that new types of detergents may result in the production of off-flavors and undesirable taste should be borne in mind also.

Problem 6.—Cost

Last, but not least, is the problem of cost. Cleaning costs money. It is desirable, therefore, that we consider what degree of cleanliness we wish to attain at any given point in the canning line so that we avoid wasting material, time and labor by continuing the cleaning process longer than is required. Standards of cleanliness are arbitrary but physical cleanliness and

bacteriological cleanliness are two degrees of cleanliness generally recognized in the food industry. Physical cleanliness is absolutely necessary not only because it is the yard stick by which the sanitation of equipment is judged but also because without it bacteriological cleanliness cannot be realized in the food industry in general.

In the canning plant the object of clean-up should be to attain physical cleanliness and in order to safeguard against spoilage special effort should be made to keep the numbers of heat resistant spoilage organisms at a minimum. This can be accomplished by cleaning and in the case of thermophilic organisms by also maintaining heated equipment in a cool condition during shut-downs and by keeping the food products out of the thermophilic range during preparation. The presence of thermophilic spoilage, therefore, may be indicative of improper maintenance of equipment and not of unsanitary conditions *per se*.

Use of Sanitizing Agents

If general bacteriological cleanliness is desired, the use of sanitizing agents may be indicated. Sanitizers may be considered as those agents which have the property of destroying or inhibiting bacterial growth. All sanitizers are less efficient in the presence of organic matter and some are actually rendered completely ineffective. It is imperative, therefore, that the equipment be thoroughly cleaned before sanitizers are applied if maximum effectiveness is to be obtained. The very act of cleaning may in itself be a sanitizing action by virtue of diluting or removing the bacterial contamination or killing the organisms by the heat or action of the detergent solution. Sanitizing agents or bactericidal compounds exert their greatest killing power with non-spore forming bacteria which are of little significance as spoilage agents in the canning industry. There are no bactericidal compounds which have proven ability to be completely effective by methods practical for use in the canning plant against the heat-resistant spore forming organisms with which the canner is chiefly concerned. These organisms are the flat sour types, thermophilic anaerobes, putrefactive anaerobes, and the sulfide spoilage organisms. This fact should be kept in mind when use of such compounds is contemplated.

The practice of blowing steam from a hose onto equipment may be effective in removing food particles and water but it is valueless as a bactericidal agent. If used with this intent, it is a waste of good steam. Steam under pressure can sterilise, but free-flowing steam has little killing effect especially when used on large metallic objects which rapidly dissipate the heat.

There is a definite need for further research and study on the cleaning problems which confront the canner. The approach to any problem, however, is a thorough understanding of the factors involved before one can arrive at any intelligent solution. We hope we have at least directed thought to these factors and the National Canners Association will be glad to cooperate to the extent that time and personnel can be made available with canners who are undertaking an investigation of methods of cleaning canning equipment.

Canning Factory Wastes and Methods of Disposal

By N. H. Sanborn, of the N.C.A. Research Laboratory

PLANT SANITATION AND WASTE DISPOSAL CONFERENCE

The treatment and disposal of waste from municipalities or industries which may cause water pollution is a subject which is increasing in importance. At least six bills have been introduced during the first session of the 79th Congress on this subject. The general tenor of these bills is exemplified by the title of H. R. Bill 519, which reads, "A bill to prevent pollution of the waters of the United States and to correct existing water pollution as a vital necessity to public health, economic welfare, healthful recreation, navigation, the support of invaluable aquatic life, and as a logical and desirable post-war public-works program." Several States are at this time revising their laws against water pollution. There is no question that both Federal and State pressure will be brought to bear upon industry in the near future. As many canners well know, the cost of a treatment plant capable of effecting a high degree of treatment is considerable and may in some cases be prohibitive. The passage of H. R. Bill 3972 would offer a measure of relief by "allowing amounts paid for plants for the treatment of industrial waste as a deduction in computing net income."

Large Volume of Water

Canning procedures necessitate the use of large volumes of water to wash raw produce and maintain sanitary conditions within the factory. Not all canners realize the extent to which such waste water can result in pollution. We all know that domestic sewage causes pollution. By means of biochemical tests the degree of pollution of any waste or sewage can be measured. Disregarding the health hazard of sewage bacteria, the pollutional effect of an average waste produced in canning peas, for example, is about 10 times as great as domestic sewage. And this is after screening through a fine mesh screen to remove solids and does not include the very strong seepage from pea ensilage stacks. Some cannery wastes may be even stronger than pea waste.

There are four general types of cannery wastes: Cooling tank water, ensilage stack seepage, gross solids and factory water contaminated with organic matter. Each requires separate methods of disposal.

Cooling tank water, except under unusual conditions, contains very little organic matter permitting direct discharge to a stream or storm sewer. Its value as a diluent of strong liquid wastes does not justify the cost of enlarging a treatment plant to handle this waste.

Ensilage Stack Seepage

Ensilage stack seepage, on the other hand, while relatively low in volume, contains so much organic matter that it is more economical to provide separate methods of disposal when stacks are located at the factory. To facilitate collection of ensilage seepage, ensilage stacks should be provided with a concrete base and drainage discharged to an underground collecting tank. The most satisfactory method of final disposal is by hauling the juice to an isolated place where dumping will not create odor nuisance or it may be discharged at a very slow rate into a stream during the following spring at times of high stream flow. From the sanitation aspect, it would be desirable to remove all ensilage stacks from the vicinity of the factory. The stacks and seepage create an odor nuisance, attract and breed flies and provide winter harborage for rodents which may enter the factory as the stacks are used up. Care should be exercised in the selection of sites for country viner stations to minimize complaints about odors and to insure against seepage entering a stream.

Gross solid material, other than that utilized as ensilage, is obtained from discarded raw material, trimmings, clean-up operations, and screenings. This waste must be removed from the factory and premises as promptly as possible to avoid odors and unsightly conditions and to eliminate breeding grounds for insects in and around the canning plant. Removal of food material which drops upon floors is desirable, not only to maintain a cleaner factory, but also because such solids create an industrial hazard by making floors slippery. Floor sweepings and other accumulations of waste material should be placed in suitable containers. Solids which enter the floor drains increase the dissolved and suspended solid content of the liquid wastes requiring treatment and increase the load upon the screening unit. Some canners find it desirable to assign a man whose duty it is continually to keep floors as free as possible from solids and excess water.

The final disposal of solid wastes, other than those utilized for ensilage, will depend upon their nature and volume. They may be given to farmers for hog or cattle feed, dumped in isolated spots or returned to fields for their fertilizer value. The Eastern Regional Research Laboratory of the U. S. Department of Agriculture, is investigating the possibilities of drying and utilizing cannery waste material for feed purposes.

Factory Waste Water

Factory waste water contaminated with organic material from washing, blanching and clean-up operations is the type of waste generally referred to as cannery waste. The successful disposal of this waste is frequently difficult. Since the characteristics of cannery waste vary considerably even for the same raw product, according to the canning procedures employed, a preliminary survey should be made to obtain the following data: Volume and characteristics of the waste, degree of treatment required to prevent pollution and otherwise comply with state regulations, and area and topography of land available for treatment plant. Having obtained this information, consideration can be given to treatment by one of the following methods: Screening, chemical precipitation, biological filtration, discharge to an impounding lagoon, or discharge to a municipal treatment plant.

Efficient screening is essential regardless of the type of further treatment required. Practically all cannery wastes may be mechanically screened through a 40-mesh wire screen. Rotary and vibrating screens are in general use. Capacity of these screening units must be sufficient to prevent overloading during periods of peak production. Every precaution should be exercised to prevent any unscreened waste from by-passing the screen unit or any screened solid material from dropping into the flow of screened waste. All too frequently failure to remove all screenable solids has resulted in complaints or inefficient secondary treatments. Only under the most favorable conditions may screening constitute adequate treatment.

Under conditions where a reduction of approximately 50 per cent in the strength of screened wastes is satisfactory chemical precipitation may be utilized. Suspended and colloidal material can be removed by this method of treatment but not organic materials such as sugars which are in true solution. The most satisfactory type of chemical precipitation plant is the so-called fill-and-draw or batch treatment in which the waste is filled into steel or concrete tanks, treated with the required chemicals, allowed to settle and finally discharged. There are a number of these treatment plants still in operation, while others have been abandoned because of their limited reduction in pollutional strength and also because of increases in the amount of waste requiring treatment. This brings up an important point. In considering the size of a treatment plant and degree of treatment required, the basis for calculation should be not the present strength and rate of factory waste discharge but rather that which may obtain in the future. A chemical precipitation plant which gave a satisfactory treatment at one time operating under its maximum reduction of 50 per cent may be entirely inadequate if called upon to treat a waste having double the original pollutional strength produced through an expansion of canning operations. The rate of production may remain the same, but the additional burden on the stream may prove to be excessive.

Very little need be said regarding the biological method of treating cannery waste by the canner, himself. While it is possible to obtain a high degree of treatment such units are very expensive and require conditioning of the biological growths upon which the method depends in advance of the application of the cannery waste. Under certain circumstances, biological filtration may become necessary but the possibilities of other methods should be fully investigated.

Discharge to a municipal plant offers an excellent means of disposal where such facilities exist or are contemplated by the city, providing suitable financial arrangements can be made between the city and cannery. It was earlier mentioned that some cannery wastes may be 10 times or more stronger than domestic sewage. If a cannery is called upon to bear the cost of treatment at the municipal plant in proportion to the load imposed by the cannery waste, the cost may well prove to be prohibitive. The attitude of municipalities in this respect varies from no charge at all to full payment in proportion to the imposed loading.

Pre-treatment Required

Some form of pre-treatment, in addition to screening, is generally required before discharge to a municipal plant. The minimum pre-treatment consists in the addition of lime at the canning plant to insure arrival of the waste in an alkaline condition. Chlorination is sometimes used. Pre-treatment by chemical treatment has proved quite effective. In a few instances canners have discharged to an impounding lagoon from which the waste is slowly discharged to the municipal plant. This method provides some reduction during the storage period and permits a controlled rate of discharge to the municipal plant over a longer period of time than the canning season.

The disposal of cannery waste by means of field absorption provides a means of completely eliminating stream pollution. Since successful operation depends upon rapid soil absorption, this means of treatment is quite limited.

Impounding of canery waste in storage lagoons can also be operated to eliminate stream pollution by retaining the waste until decomposition of organic matter permits a safe discharge. Untreated lagoons develop considerable odor necessitating their location in isolated spots. This feature has greatly restricted the use of such lagoons. During the past several years, a method has been developed which permits control or practical elimination of offensive odors, thus permitting the wider use of lagoons. Practically all of the treatment plants installed by canners during the last 4 years have been treated lagoons or conversions of untreated lagoons.

Lagooning Problems

The chief obstacle to the use of lagoons consists in obtaining a site large enough to hold the waste and yet within practical pumping or piping distance. For the seasonal cannery, it is desirable to impound the entire waste output in a single lagoon. Packers operating the year-round require the use of several lagoons. The lagoon site must be so located that there is no possibility of seepage entering walls.

A large shallow lagoon materially assists in controlling odors by providing better natural aeration and greater stimulation of sunlight on certain beneficial forms of biological life. A depth of 5 feet is the maximum which should be used and if area permits a depth of 3 feet will permit more effective odor control. A lagoon 3 feet deep requires an area of 1.02 acres per 1,000,000 gallons of waste while with a depth of 5 feet the same volume can be contained in 0.61 acres, both areas being exclusive of the area occupied by the lagoon walls. To avoid overfilling the lagoon, it is necessary to know that total volume of waste requiring treatment. The capacity of the lagoon should be increased by 25 percent to permit the retention of this extra volume of waste in the lagoon at all times. Retention of approximately 25 per cent of the waste in the lagoon has three advantages: (1) Dilution of incoming raw waste, (2) retention of a large amount of biological life required for rapid purification, and (3) maintaining a layer of liquid in the lagoon to prevent the growth of weeds. Weeds being of organic composition decompose and produce odors in the same manner as untreated cannery waste. These three factors are important in securing the desired and nearly odorless decomposition of cannery waste, but in themselves are not sufficient.

The organic material in cannery waste undergoes rapid decomposition. If decomposition proceeds in the absence of a sufficient amount of oxygen, obnoxious odors are produced. It is therefore necessary to maintain the presence of oxygen. This is accom-

plished in four ways: (1) By natural aeration which is limited by the solubility of oxygen in water, (2) by the dissolved oxygen content of the liquid retained in the lagoon, (3) by certain forms of biological life, and (4) by the addition of nitrate of soda which contains oxygen in a form readily available for the aerobic organisms. To the extent that these conditions are met odorless decomposition will be obtained.

Nitrate of soda can be obtained from dealers handling fertilizers. It is easy to add to the waste and should be applied after screening and before discharge to the lagoon. A water solution of the nitrate may be made and fed to the waste at the pre-determined rate or the nitrate may be added in the dry state from time to time during the course of the operating day.

Because of the increasing necessity for adequate waste treatment, every canner should reconsider his position in this respect. If he is satisfied that no future problems will arise, he is indeed fortunate. If he may be faced with a problem, tentative plans should be developed as soon as possible. If, for example, a lagoon site will be required, negotiations for its purchase should be started well in advance. To wait until it is needed has on more than one occasion resulted in either inability to secure the best site or the payment of an exorbitant price.

Any form of waste treatment requires an understanding of its operation and limitations. Of necessity, many important features have been omitted from this brief discussion of cannery wastes. For more detailed information, reference should be made to N.C.A. Bulletin 28-L in which the chemical precipitation and biological filtration methods are described and to Bulletin 29-L for detailed information on lagoon treatment.

TABLE OF CONTENTS